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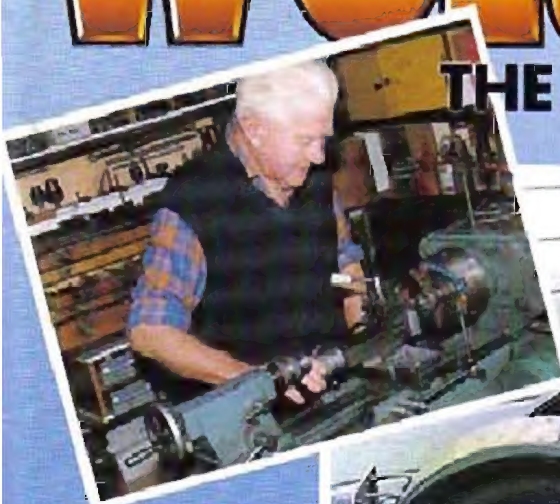
FEBRUARY/MARCH 1993

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MODEL ENGINEERS'

WORKSHOP

THE PRACTICAL HOBBY MAGAZINE



**MAKE A
'TWIDDLE
-STICK'**

**FULL-SIZE
RESTORATION**
In the home workshop



METAL SPINNING
**MORE
D.T.I. DODGES**

**PULLOUT
PLANS!**

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to vertical
slide**

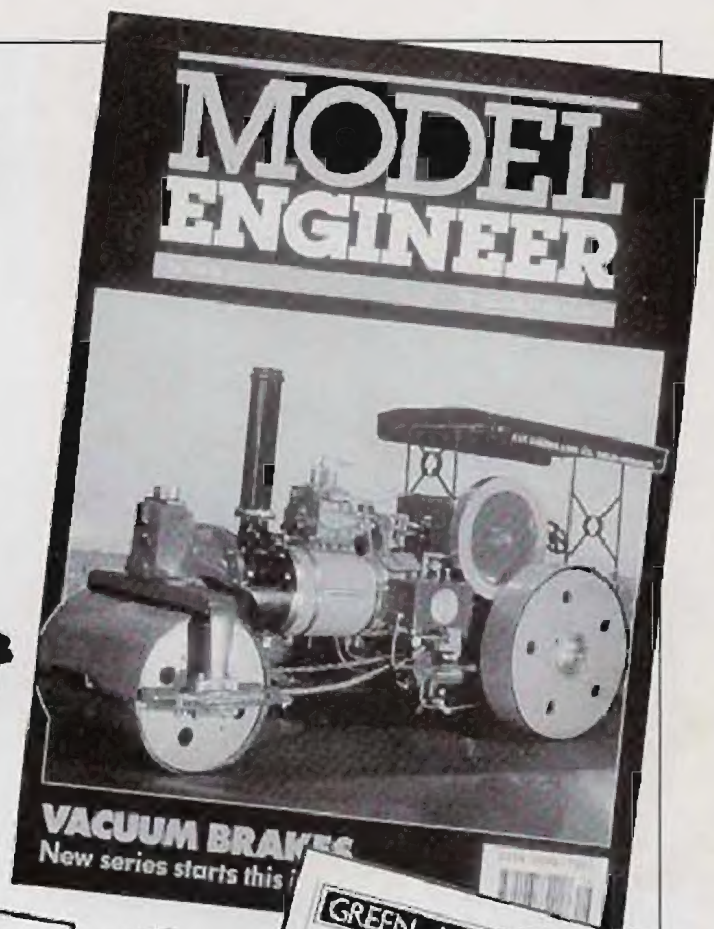



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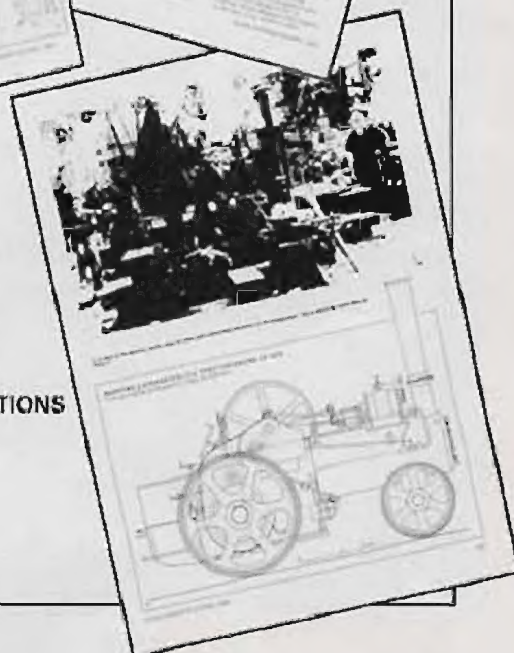


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...every fortnight



There's something to anticipate twice every month in fascinating Model Engineer magazine! Whether your interests lie in live steam locomotive models, traction engines, internal combustion motors or stationary engines, world famous M.E. will inspire, instruct, advise and encourage. Model Engineer is published on the first and third Fridays each month and costs just £1.40 from all good newsagents; alternatively, you may care to ensure your regular copies through an annual subscription - a mere £33.60 for UK readers (overseas rates and airmail details on request).

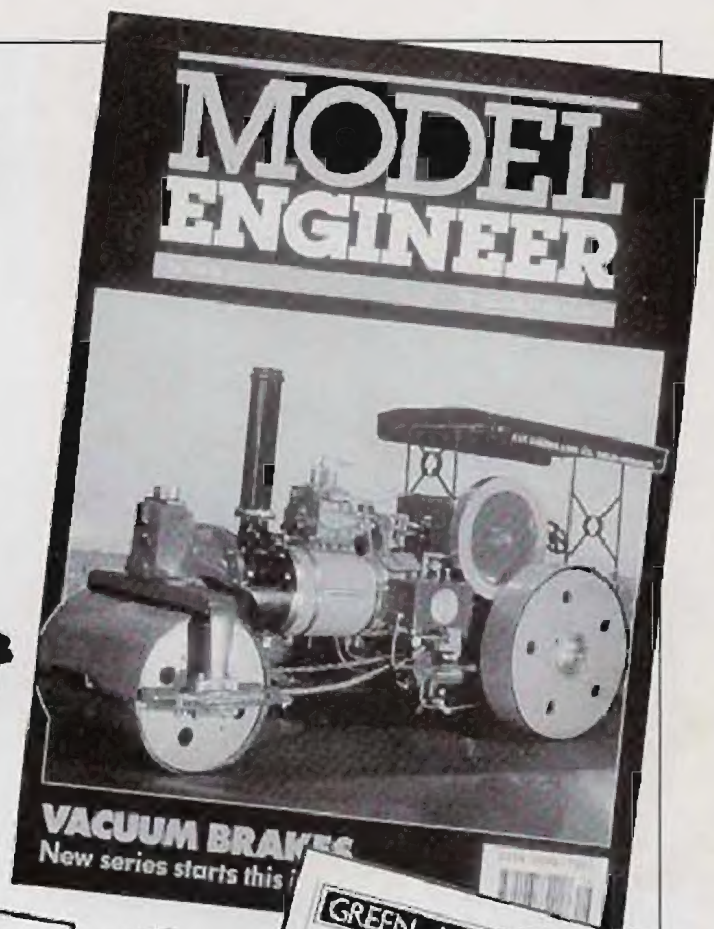


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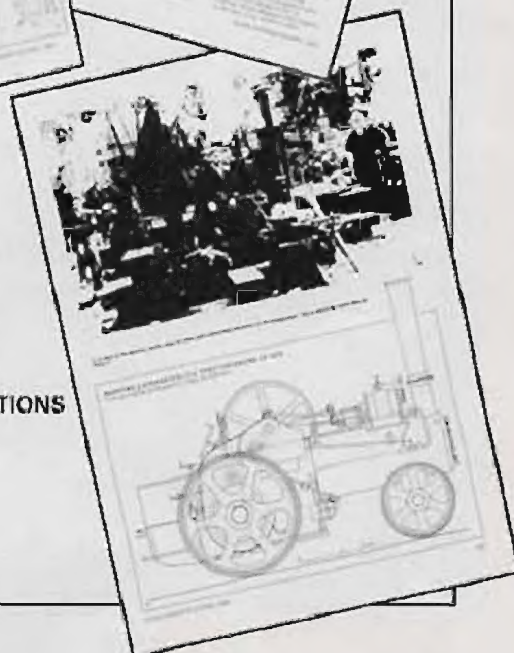
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Harold Hall

ON THE EDITOR'S BENCH

As I write *On The Editor's Bench* for this issue I have just visited The Midlands Model Engineering Exhibition at The Royal Showground Stoneleigh, but as you read this, the 62nd International Model Engineer and Modelling Exhibition at Olympia will be well under way, if not over. This serves to highlight the time lapse between my involvement with an issue and your reading it, and which makes it difficult for comments in *M.E.W.* to always be topical.

Exhibitions, whilst always interesting to visit, rarely have much on display that can be considered new. One such new item that was on display at Stoneleigh, and no doubt will be at Olympia, was a new small lathe from HobbyMat called the Minuturn 200. It is a little smaller than the MD65, which still remains available, but has marked similarities, coming as it does from the same factory. Brief details of this lathe can be found in the trade pages.

Whilst talking exhibitions I would add that CAD/CAM '93 will take place at the NEC Birmingham from the 9th to the 11th March. This is an exhibition obviously intended for industry, but whilst most of what is on display is far too expensive for use at home, it is none the less interesting. There are though frequently demonstrated drawing packages which could fall into the price range of the home machinist. An article on CAD in the home workshop is planned for the latter in the year.

Electric motors

One subject that frequently occurs in correspondence to *M.E.W.* probably more than any other, is that of electric motors and their application, often these questions relate to surplus motors of uncertain characteristics. To attempt to include in *Model Engineers' Workshop* an article that would resolve all these problems would be wishful thinking, as it would be bound to fail in its aim. More important would be, that due to its shortcomings, readers may at best waste money due to failed projects, whilst much worse the safety of user and equipment may be jeopardized.

I cannot therefore consider publication of an article dealing with surplus motors in general, though the use of low voltage motors from scrap motor cars, that can be acquired cheaply, is probably an acceptable exception. This does not mean that articles on the subject of electric

motors cannot find a place in the magazine. Starting in this issue, we have, the first of a four part series on electric motors and their potential for speed control, covering in this issue, the subject of AC induction motors. This goes into some depth, which hopefully will increase the interest gained from reading the article, and as a result make the facts easier to remember for future recall.

Part two will predominantly cover the commutator motor when used on DC, but with some comment on their use on AC, this second part will be even more technically demanding. Because of this, I would like to hear from readers, whether or not they consider this degree of technical content acceptable in a magazine like *M.E.W.* Part three will consider the application of speed controllers to AC induction motors, including a review of some speed controllers available commercially. The construction of such controllers in the home workshop is unfortunately not a practical proposition. Part four will cover the subject of speed control of DC motors and will include some constructional projects. These controllers will be limited to relatively low powers, the reason being is that the cost of DC motors suitable for driving the average home workshop machine would be prohibitive.

Readers' workshop activities

The readers' survey conducted in the October/November '91 issue of *Model Engineers' Workshop*, showed that the interests of our readers covers a wide range of activities. Whilst model engineers make up by far the largest single interest, correspondence still shows the range of tasks undertaken is very wide.

Second to model engineering are a large number of readers who largely make tools and attachments for their workshop. It is probable that this is with the idea of taking on some more time consuming project when the workshop is more fully equipped. For many, time in the workshop is, and probably always will be, a limited resource, because of this, projects which require a considerable expenditure of man hours are out of the question. Many of the projects included in this magazine, give an opportunity for those with limited time, the possibility of having the pleasure of workshop activity and with a finished and useful item in a matter of a few tens of hours, perhaps being their only project over the course of a year. I have, in the past, almost always been limited to this level of activity, on one occasion only, being able to devote more time to a modelling project.

Of other activities, restoring vintage motor cycles and to a lesser extent cars is quite common, as is making and restoring clocks. As an example of these other activities, we have in this issue, a visit to the workshop of Albert Wallis who's interest has been for many years the restoration of Brough Superior motor cycles. Albert has only recently become aware of *M.E.W.* and, like so many, is very keen to obtain all the earlier copies to complete his set.

New readers

Correspondence being received, shows that there are still many who are coming

across *M.E.W.* largely by chance. Those who write, all comment on how pleased they are with the magazine and many wish to obtain back issues to make up the set. From this it is obvious that there are still those who do not know of the existence of *M.E.W.* Advertising could be considered, but with the wide range of interests, as indicated above, where could this be done. I would like to request therefore, that if you have interests common with other people that will not have seen the advertising in *Model Engineer*, that you talk about *M.E.W.* with your friends. Any new readers that result will be of benefit to the publishers, but will also be of benefit eventually to the readers. A wider circulation will help limit costs and attract more and better contributors.

To mention again, as I did in an earlier issue, the question of early issues of *M.E.W.* These are much in demand and should you require to dispose of yours to make space for new issues, please do not consign them to the bin as there are many readers desperate to give them a good home.

Quick tips

The stock of available quick tips is rapidly diminishing, as a result, I include this plea for readers to share their favourite ideas for making a task just that bit easier. Whilst on the subject of quick tips I must apologize to some who have recently provided tips. As a result of the tips becoming separated from the letters they were sent with, the authors' names have been unavailable for publication.

Request for an article

Another reader interest that has been mentioned on a few occasions, surprisingly, is making full size yachts. This entails much working in stainless steel when making the various metal components. There have also been recently in *Scribe a Line*, and in some articles received, (but maybe not yet published) mention of the problems associated with the working of stainless steel. Is there any reader, maybe one of our yachting enthusiasts, who could write an article on the subject of machining stainless steel? If you are unable to write a full article but feel you have some knowledge of the subject that could be shared in the form of a letter, please do write in with your contribution. This can either be used in *Scribe a Line* or alternatively as a *Quick Tip*.

It has been noted that over the past few months the number of articles being received has reduced considerably, no doubt due to other activities having priority during the summer period. Now that the summer is over and winter is keeping you indoors more often, why not take this opportunity to put pen to paper. It would be preferable however to write to me with brief details before spending time on a complete article, just in case for any reason your article would not be considered suitable.

Final Request

Would the reader who sent in a dovetail cutter to Classified Ads please make contact with me.

SCRIBE A LINE

Your views, your pages! Your opportunity to make your point, ask the question or simply pass on a snippet of interesting advice to others. Your letters for publication in *Model Engineers' Workshop* are always welcome



Motor cycle model

In view of its relevance to this issue I include this very brief extract from a letter received from Henry Tindell of Cheadle Hulme.

I enclose herewith a photo of a model figure I have made. It is of a 1931 Brough Superior model SS100 it is about 2½ in. high and is mild steel and braze welded. This is an example of a wide range of small items that I make from sport, music, transport, etc. which are used for presents or for trophies.

Congratulations on a most interesting magazine which I am glad to see is becoming more widely available now.

Why?...

Mr R Knee of Lowestoft says:
'Why Don't They?'

Why don't lathe manufacturers supply a bored and screwed chuck back plate instead of a catchplate, which doesn't do anything that the faceplate can't do as well?

Compressors and Conversions

Roy Campbell of Bromsgrove comments on recent items in M.E.W. relating to compressors and inch/metric thread conversions.

Compressors

Having belatedly read the October/November issue may I add a few thoughts on my own experience in building a compressor unit, particularly when creating a system out of odd parts. The main problem, I found, was matching the motor to the compressor and providing a sufficient output of air.

Spare motors of greater than ¼ h.p. are rarer than hens' teeth but, given the right pulley diameters, such motors can sustain up to 3 cu. ft. per min. of free air displaced. The big problem was always starting the unit against a full head of air, typically 90 to 120 psi, especially in an unheated workshop in winter. The results of much calculation and many experiments showed that a 1:1 pulley ratio could maintain steady state output from a 2 cfm compressor with a 1440 rpm 0.5 h.p. motor. Starting, per the above, was always a major problem, however.

The solutions, incorporated over a period of time, were:

1) Obtaining a twin cylinder compressor (from a scrap milk cooler). With the same

capacity as my old single, each piston had only half the area for the motor to work against and as one piston was up when the other was down the starting load was greatly reduced.

2) Inserting a T-piece with a hand wheel valve in the output from the compressor. This was opened on starting and was closed when the motor ran up to speed a few seconds later. NB: Automatic unloaders from truck compressed air brake systems will also do this but I could never find one.

3) Mounting the motor on a hinged plate with a lifting handle, allowing the weight of the motor to act as an automatic belt tensioner. Lifting the motor allowed the motor to hit full speed instantly, followed by gently lowering the motor allowing the V-belt to slip like a clutch until it was fully engaged.

4) Finally, quite important in cold conditions, I changed to a low viscosity oil. The best by far was Citroen LHM Brake Fluid (Liquide Minerale Hydraulique I think) or Castrol CHSMO (Central Hydraulic System Mineral Oil as used in Rolls Royce and some Jaguar systems). Note that this is not normal synthetic brake fluid which

must not be used, but is a true mineral oil suitable for pumps and gears. Its pour point, however is below minus 60 deg. which is why it has such little drag at around the normal freezing point.

Until I could afford a 'proper' compressor my home-built hybrid incorporated all of the above features very successfully, being used on several occasions to spray complete cars - albeit slowly.

Metric and imperial screwcutting

Having pensioned off my old flat belt drive lathe (make unknown) in favour of a metric Bofford AUD, I have anticipated some problems in producing UNF, BSF and BSW threads without going to the trouble and expense of acquiring the necessary imperial gears. Prompted by Mr D.R.W. Wooten's letter I offer the attached chart for comment. For a range of Imperial TPI's (12 to 28) I have selected the nearest metric pitch available on the Bofford and then calculated the accumulated pitch error over the length of a typical nut. Apart from the 12 and 14 TPI cases, and possibly the UNF 24 TPI, the 'nut error' does not appear unacceptable. I say this on the basis that there will be some tolerance in the system and also that various shake proof nuts also have controlled distortion (hence friction) built in. I accept that some combinations may not spin freely down the thread but that may not be a problem.

I would emphasise that I have not yet experimented with this approach and offer the suggestion as a contribution to the debate.

Bofford metric screwcutting lathe used for inch threads
Errors over typical nut lengths.

TPI	BSF	BSW	UNF	Pitch inches	Pitch mm	Nearest metric	Nut length	Nut error
12	¾	½	1-1.5	0.0833	2.117	2.200	0.75	-0.030
14	⅞	⅝	¾	0.0714	1.814	1.875	0.75	-0.025
16	⅞	⅝	¾	0.0625	1.588	1.600	0.65	-0.005
18	⅞	⅝	¾	0.0556	1.411	1.400	0.50	0.004
20	⅞	⅝	¾	0.0500	1.270	1.250	0.37	0.006
22	⅞			0.0455	1.155	1.125	0.25	0.006
24			¾	0.0417	1.058	1.010	0.24	0.011
28	⅞			0.0385	0.977	1.000	0.22	-0.005
28			¾	0.0357	0.907	0.900	0.22	0.002

(The important consideration is the error compared to the pitch of the thread. Around 35% for the 3 worst cases, the remainder 10% or less. Ed.)

Square holes

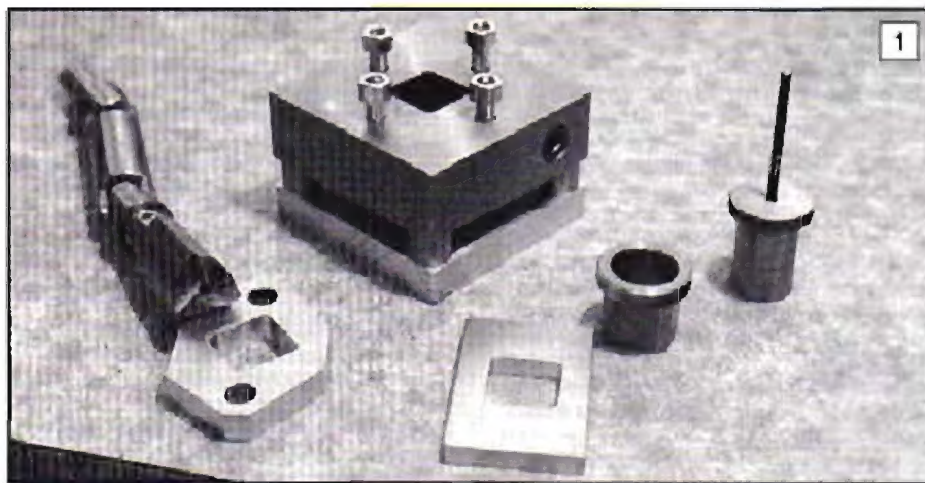
This letter with photos from Nigel Whiteway, adds his experiences to article on drilling square holes. It adopts the same basic principle as that by Derek Winks, but being of a more complex construction is capable of producing much larger holes.

I note that you have published details of a drill which will produce square holes. I have recently made one of these as an experiment as can be seen in the photographs.

The idea stemmed from an article by David Piddington in a recent edition of *Model Engineer*. This article describes how to make the basic three sided roller which, despite its uneven shape, runs amazingly smoothly on a flat surface. This is due to

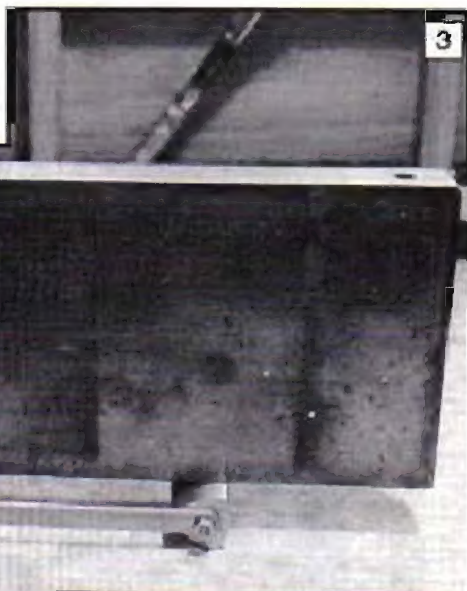
the constant rotating diameter offered by the accurately machined 'roller'. (As used in the rotor of a Wankel engine). **Photo 3** shows two of these rollers linked together and this combination has intrigued many of my friends as it demonstrates the principles involved very well. The picture also shows my 'square hole drill'.

The bit used in the 'square hole drill' is simply a slightly longer version of the 'roller', produced from silver steel, with cutting teeth added, and finally hardened. Two universal joints are then inserted between the bit and the drill to allow free movement of the bit in the jig. **Photo 1** shows the complete jig and drill set, together with a couple of samples of the results and **photo 2** shows the set up in operation on the drilling machine.



This is how I achieved the end result - First, drill a $\frac{1}{16}$ in. hole in the centre of the work piece to act as a guide. Now use a $\frac{1}{16}$ in. drill to remove most of the metal. The epicyclic drill will now remove the rest, leaving just a $\frac{1}{16}$ in. radius in the corners. (These are left because the 120 degree plus angle between the sides of the drill will not fit into the 90 degree angles at the corners of a completely square hole !!!) (A true flat sided triangle would give much squarer holes. Ed.)

I enjoyed reading your article on the subject and always enjoy reading Model Engineers' Workshop. "Great stuff - Keep 'em coming."



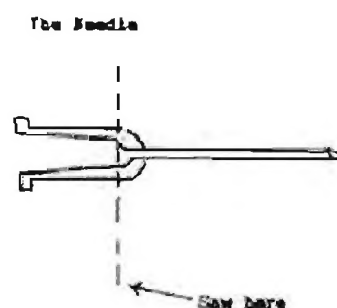
Oiling Myford lathes

In this letter we have suggestions for overcoming at least one of the problems encountered when oiling a Myford Lathe. This has been sent by Dr D.W. Ross of Lewes.

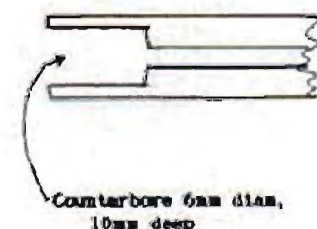
I take the liberty of sending you a small contribution which you may care to use. It is no more than a report of a chance discovery which I felt might be of interest to fellow readers. The publication from Camden Min. Steam to which I refer below is "A Treatise on Oiling Machine Tools, or A Myford Owner's Fondest Dream Come True"

May I take this opportunity to thank you for a magazine that is always of interest and most enjoyable.

ILLUSTRATION NOT TO SCALE



The "business end" of the oil-gun.



Oiling the Myford Lathe

Many readers will have purchased the publication from Camden Miniature Steam describing the conversion of a grease gun for use in injecting oil into the nipples of a Myford Lathe. One of the suggested, but untried modifications to the conversion, is the proposition that it should be possible to improve the seal between the delivery end of the oil gun and the nipple by inserting "some form of hard plastic sleeving". I write to report my discovery that the standard disposable NHS issue No1 hypodermic needle has a hard plastic haft which by chance is a nice fit on the Myford nipple. The haft of a hypodermic needle has a tapered bore known as a Luer fitting (the medical equivalent of a Morse taper). The metal needle is sawn off and discarded. The delivery end of the oil gun is bored out to a suitable diameter so that the plastic haft is an easy push fit into it. Batches vary, but 5.5mm to 6mm is about right for most needles. When the Luer end is forced onto the nipple for the first time the plastic stretches to be a good fit in the counterbore and the oil seal obtained will

Safety and students

Mr G.W. Reeve writes regarding his appointment as college safety officer, also the efforts of his students who have made items from M.E. and M.E.W. We wish him well, particularly when wearing his safety hat.

Two or three weeks after publishing my letter in issue eleven of your magazine referring to matters of Health and Safety I was appointed College Safety Officer in addition I hastily add to my lecturing duties.

My letter was seen and read and commented upon, therefore I suppose the authorities thought that since I was interested enough to write on safety matters to you and you took the comments seriously enough to publish them I was the

man for the job.

You may also care to know that one of my first year apprentices in the last academic year manufactured a copy of the Toolmakers Hammer that was published in issue 8 of M.E.W. as an entry piece to a local Apprentice of the year competition. His effort was rewarded with a Highly Commended certificate at a ceremony in Nottingham earlier this month.

Two years ago one of my students won the competition outright with an unusual design of tap wrench that was featured in a thirty year old copy of Model Engineer Magazine.

The lesson of course is that our hobby satisfies not just the amateur engineer and that we can always learn whatever our age whatever our experience.

be very good indeed. In practice, I find that one needle haft lasts me two or three months before the bore of the plastic becomes a loose fit and needs replacing. These needles can be purchased cheaply from any chemist (they usually stock the No 20 for diabetics, smaller bore but same haft) or can be a gift from your local friendly GP. The original article specifies an American make of grease gun, but I successfully converted an old Tecalmit of U.K. origin which had been knocking about my garage for years.

Modified Belt Sander

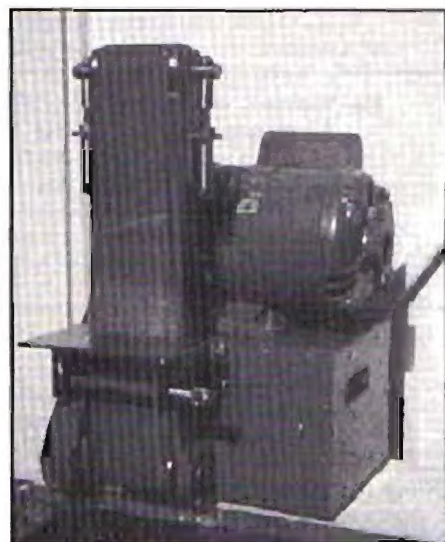
Jack Webster has made, with a few mods on route, the belt sander provided for us by Bluey in the Winter 90/91 issue.

This is my version of the belt sander described by Bluey in M.E.W. Winter 1990/91.

It is a great machine that does away with a lot of filing, all in all a big asset to any home workshop. The belt frame and rollers are as per Bluey, but a little wider, the belt being 36 x 3 inches.

The base was prefabricated from 10 s.w.g. plate, $\frac{3}{4}$ x $\frac{3}{4}$ x $\frac{1}{16}$ in. angle with bar fillets and a lot of $\frac{1}{16}$ in. rivets. It is fitted with a M.E.M. push button starter Cat. Auto Memo 22 A.D.S. controlling the $\frac{1}{2}$ H/P single phase motor.

The whole thing is stood on four $\frac{1}{2}$ in. rubber door stops that holds it very firm when in use.



Spinning

Alan Jeeves, the author of the metal spinning article in this issue, comments on the letter on the subject in the last issue.

It is nice to see Mr R. Jeffery showing us his work in 'Scribe a Line', especially as he includes photographs. This is a first class example of metal spinning in the home shop.

Being the author of the article on metal spinning I read his comments with interest. I agree with his encouragement 'have a go' because I think that many people will be surprised by the results of their efforts. I do think, though, that Mr Jeffery may have innocently included a few words of discouragement to would-be spinners in that he had to anneal the work about eight times during production. The amount of forming here is comparatively light in terms of spinning small objects and even

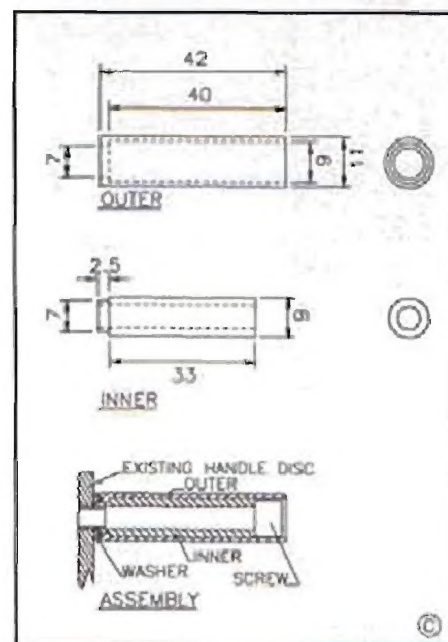
using B.S. 899 half hard brass sheet in 16 gauge (1.6mm) I would expect to spin the dome in one chucking. I might even consider spinning a 'one off' without a former at all. I guess the clue is in the tool being used. It is clamped in the tool post and, in my view, is not as sensitive a method as 'freehand' spinning. If the tool is allowed to 'dwell' on the job too long, work hardening will occur very quickly indeed. I would carry out the whole of the roughing out with the 'tongue' tool and would pass over the metal briskly to avoid much work hardening. To finish it off I would use the planisher to remove the tool marks clearly seen in photograph 3. Anyone contemplating metal spinning, please do read the article in M.E.W., especially concerning the tools and toolrest. (Safety too, of course). It may be a whole new avenue to explore.

A Hobbyist handle

Brian Fair considers the Hobbyist MD65 to be a very good lathe, but like most things there is always room for improvement. He suggests an improved lead screw handle.

I own one of the very good Hobbyist MD65 lathes and was overjoyed to see Mr Shepherd's excellent article. One item he did not include was a lead screw handle which does not make the right hand sore at the end of a long session. I believe that there is a commercial item which may be purchased but have never seen one. I designed and built my own. All measurements are variable to taste. The handle is in 4 parts. All measurements are mm.

- i) Socket head screw 5 x 50
- ii) Outer handle BMS 42 x 11 drilled 7mm and then bored or drilled 9mm to a depth of 40mm. Chamfer the edges.
- iii) Inner handle, I used bronze but brass or



BMS would do. 9mm x 42 minus the depth of the head of the screw. Drill for the screw and turn down about 2.5mm at one end to 7mm to fit the hole in the outer handle.

iv) A suitable washer to fit between the handle cluster and the disc of the lead screw end.

All fits should be of the rattling good variety and a little molybdenum disulphide

grease applied to all rubbing surfaces before assembly.

I have taken to metal work after many years as an aeromodeller, a hobby which continues in parallel. I find M.E.W. the best balanced mixture of beginners and progressively more advanced articles available. Please arrange that it long remain so.

Barker lathes

Can anyone help Mr R. Stageman of Great Yarmouth by providing details for his Barker lathe?

I would ask whether any reader has a manual or other working data for the 1950's Barker lathe.

Speeds and feeds

Do you calculate the speed and feed rates when operating your machines? Mr R.S.P. Amos of Australia suggests you should, but to work it out just the once for the range of speeds available, then to retain it in tabular form.

Very few (if any) machine tools in home workshops have continuously variable speeds. Thus for a particular job a selection must be made from the available range of fixed speeds.

Job sizes however range from zero to the upper limit which can be fitted to the machine. There is also the nature of the material to be taken into account. Thus job size and material are the independent variables and speed and feed are the dependent variables.

Many publications list data on recommended speeds and feeds for lathes, drills and mills, but it is a bit of a chore working out the arithmetic on each occasion. I have found it convenient to do this in a once only session and tabulate the results in terms of the particular speeds available on my machines.

I have produced 3 sheets for drill, lathe and mill, which show for each class of material the maximum size of material or size of tool for each available speed.

The basic information from which these tables have been derived comes mainly from Tubal Cain's Model Engineers Handbook (Argus Books, £6.95 plus £1. p&p).

Subsequently, I have noted that for milling there is another constraint because I have only a limited range of cutters available thus a fourth table has been generated which shows for each class of material and each size of cutter the speeds and feeds appropriate.

I have spoken to some who feel that the tables "are too precise for use with the average model engineer's lathe". This misses the point which is convenience, not precision.

The matter is essentially a do-it-yourself exercise, and the decision for each individual is whether to run through the arithmetic once for all possible cases for his own machines and tabulate, or alternatively to accept the tedium of doing it for every job that comes up.

I find the once only approach more convenient and other readers may also.

White metalling

Mr E. Ellis of Dunsley sent this letter regarding white metalling having read the article on the subject in the Oct/Nov 1992

issue of M.E.W.

I found the recent article on whitemetalling most interesting and informative.

Having carried out the process on various bearings on a preserved steam locomotive (yet another reader interest, Ed.) I would endorse the comments about getting whitemetal to stick to cast iron - it is the very devil!

Several bits of useful information. The first is to wear a full face mask with brow and chin guard (to BS 2092, of course) as well as all the other protective clothing. Secondly, I have found that using a candle flame is a cheap (but lengthy) method of blacking a mandrel.

Thirdly, white metal specification used to be covered by BS 3332 (and may still be). This gives 9 grades for various types of work, but I don't know whether they are all available commercially.

Finally, a video entitled Living with Lizzie Part II contains some scenes of white metalling, and also re-leading a fusible plug. It also shows what happens when whitemetal meets damp fire clay. This was deliberately done, and shows why safety equipment is vital.

(For details of video send a stamped addressed envelope to Mr J. Wildy, Vale Video Ltd., Tindale Road, Slimbridge, Glos.).

Electric ovens

This interesting approach to building an electric oven was sent in by Mr A.W.F. de Ville of Hythe.

I made my furnace with the following materials - a disused

spin dryer drum, a ring and a grill element from an old electric cooker, a large wooden box, some sand and two fire bricks.

Half fill the drum with sand with a topping of broken fire brick. Place the ring element on the broken fire brick and bolt the element to the side of the drum, passing the wires through holes drilled to suit, including the earth wire from the bolt.

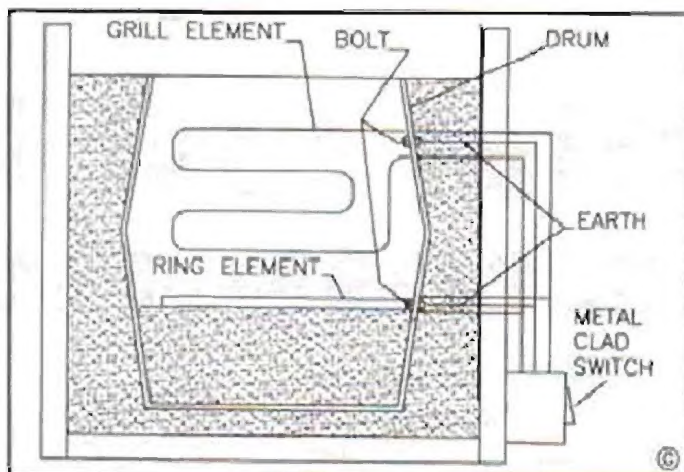
Bend the grill element into a half circle and bolt inside the drum as before together with the wiring.

The elements were attached to the inside of the drum by a single bolt through the fixing plate, in the same manner in which they are attached to the electric stove.

With regard to the wiring the ideal would be to use the same type as on the stove. I did not have such wire so I used suitable lengths cut from heavy duty electric cable.

Construct a large wooden box out of 3/4in. plywood and place the drum inside, packing all around with sand. Carry the wiring through the side of the box and connect to a metal clad 13A switch.

As the wires must run from the elements through the hot sand and out through the sides of the box it would be advantageous



to thread the wires through short lengths of a burnt out pencil type electric fire element. Each individual wire should be kept apart from the others as they pass through the sand.

I used two fire bricks to cover the top of the drum. It takes approximately 1 hour to melt aluminium in a crucible.

I have used the furnace several times for periods up to 2 hours and so far without any element burn out.

QUICK TIP

When using letternumber stamps, it is a good idea to start writing with the last character first. Writing backwards means your left hand does not blind the letters you have already stamped and an even line can easily be achieved.

Alan Jeeves

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Dial test indicator accessories

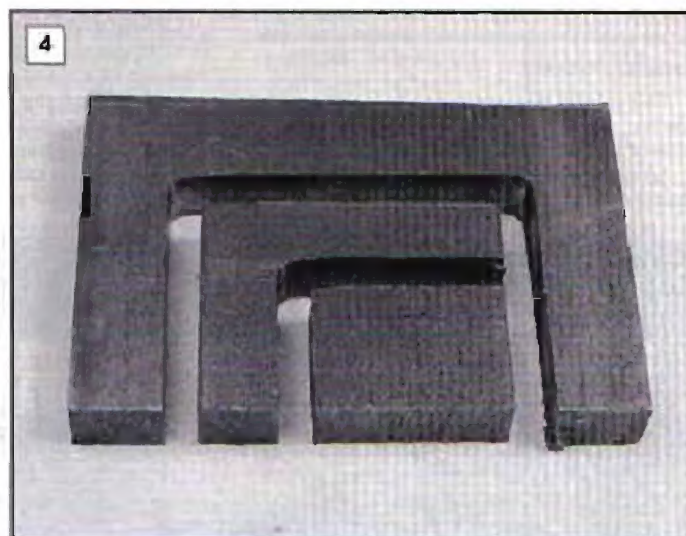
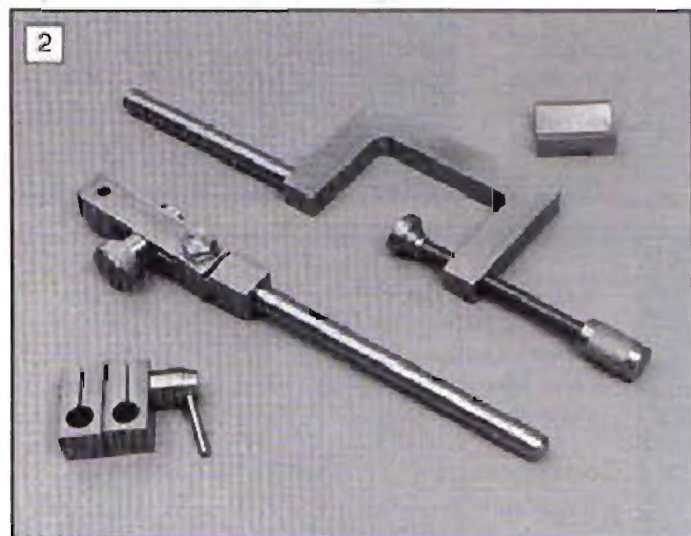
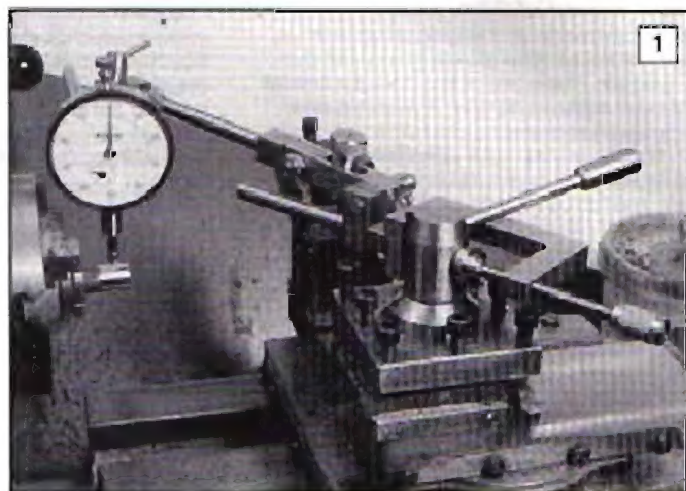
PART 2

We continue with the second part of this series for a dial test indicator accessory. This time we see how its uses extend well beyond those initially set out for its use with the D.T.I.

Last time, this series started by suggesting the basic items required for mounting a dial test indicator on either the lathe or the milling machine. In this issue, this usage will be expanded on, but also suggesting quite different applications using the same items together with some new attachments.

The method of mounting the indicator to

the lathe in the last issue was by means of the right angle arm. This, a simple and robust method, can be inconvenient as it occupies a tool mounting position. It can as a result necessitate the removal of a tool from the tool post. Two additional methods of mounting the assembly are now proposed, these will find use on the lathe and the milling machine, and many



1: Using the clamp and fine adjustment assembly to mount the D.T.I. on to a lathe.
2: The clamp with its vee block, fine adjustment assembly, and a pair of arm clamps.

3: No material wastage here. Three parts from the same piece of BMS.
4: The three parts: clamp body, Vee block and the D.T.I. internal attachment (to be detailed in the next issue).

other situations. The first is a simple G clamp with integral arm; included with this is a loose Vee block to enable it to be clamped securely on to round items.

The other arrangement comprises an arm holder, very much like the arm holder mounted on the milling machine in the last issue. In this case, the holder can be mounted to the lathe cross slide or milling machine table using special Tee bolts. The arm

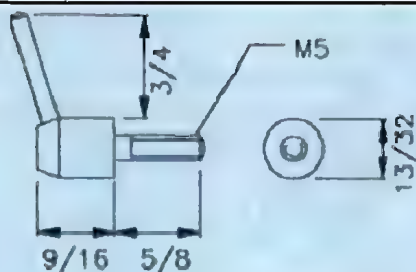
holder can also be fixed to a base to make a free standing unit.

G clamp with arm

The G clamp can be seen in use in **photograph 1**, in this case being clamped onto a round item and with the small vee block also brought into use. The Vee block is a loose item which is in no way fixed to the clamp, it does though have a shallow slot which helps it to locate adequately, this can just be seen in the photograph. The clamp with its separate vee block are shown in **photograph 2**.

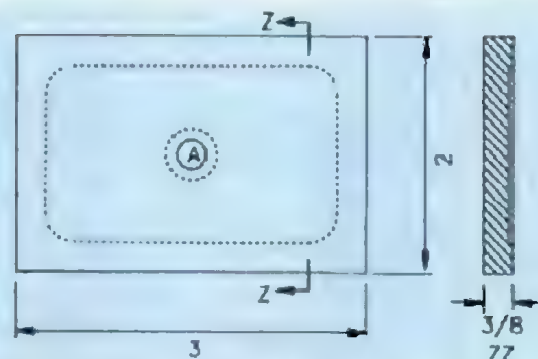
Like the fine adjustment unit, also shown in **photograph 2**, the clamp is detailed as having a fixed length arm. In the last issue, it was suggested that the fine adjustment unit would benefit from having a removable arm to allow different lengths to be fitted, the clamp would also benefit from such an arrangement. Again the use of a grub screw, suitably positioned, would make this possible.

First cut a 3in. plus length of BMS 2in. x 3/16in. machine the cut ends to give a satisfactory finish. Then with the piece



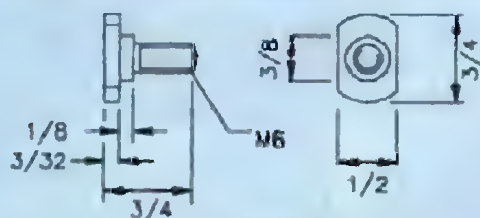
MATERIAL 7/16 dia BRIGHT MILD STEEL.
1/8 dia BRIGHT MILD STEEL.
QUANTITY AS REQUIRED.
SHAPE GENERALLY AS SHOWN.
FIX ARM USING SUITABLE ADHESIVE.
CLAMPING SCREW.

©



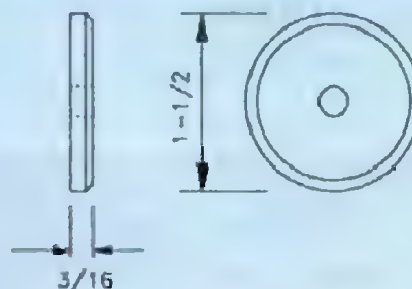
MATERIAL 2 X 3/8 BRIGHT MILD STEEL. 1 OFF REQ.
HOLE A 1/4 CSK FOR M6 SCREW.
RELIEVE BASE AS SHOWN 1/32 DEEP. **BASE.**

©



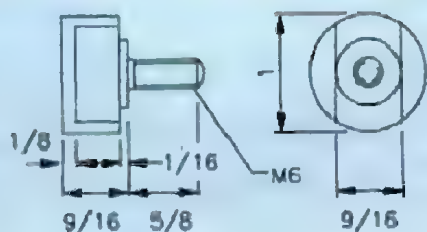
MATERIAL 3/4 dia BRIGHT MILD STEEL.
QUANTITY 1 OFF.
SMALL TEE BOLT.

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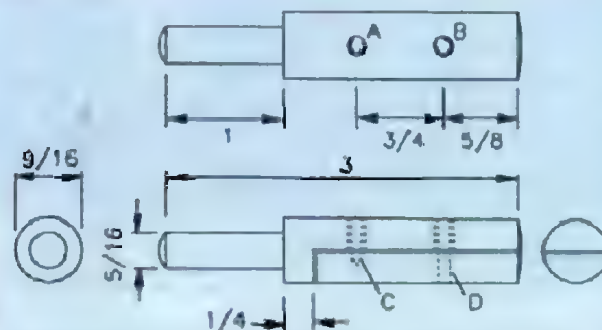
MATERIAL 1-1/2 dia BRIGHT MILD STEEL.
QUANTITY 1 OFF. HOLE 1/4 dia.
LARGE TEE SLOT WASHER.

©



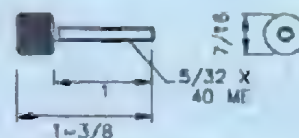
MATERIAL 1 dia BRIGHT MILD STEEL.
QUANTITY AS REQUIRED.
LARGE TEE BOLT.

©



MATERIAL 9/16 dia BRIGHT MILD STEEL.
QUANTITY 2 OFF.
HOLES. (BEFORE SLITTING)
A. 3.4 mm 3/8 INCHES DEEP.
B. 3.4 mm THROUGH HOLE.
CUT INTO TWO PIECES AS SHOWN DOTTED
HOLES. (AFTER SLITTING)
A. 5/32 X 40 ME.
B. 5/32 X 40 ME.
C. 11/64 X 1/8 INCH DEEP.
D. 11/64 THROUGH HOLE. **CLAMP BODY.**

©



MATERIAL 7/16 dia BRIGHT MILD STEEL.
QUANTITY 4 OFF.
CLAMP SCREWS.

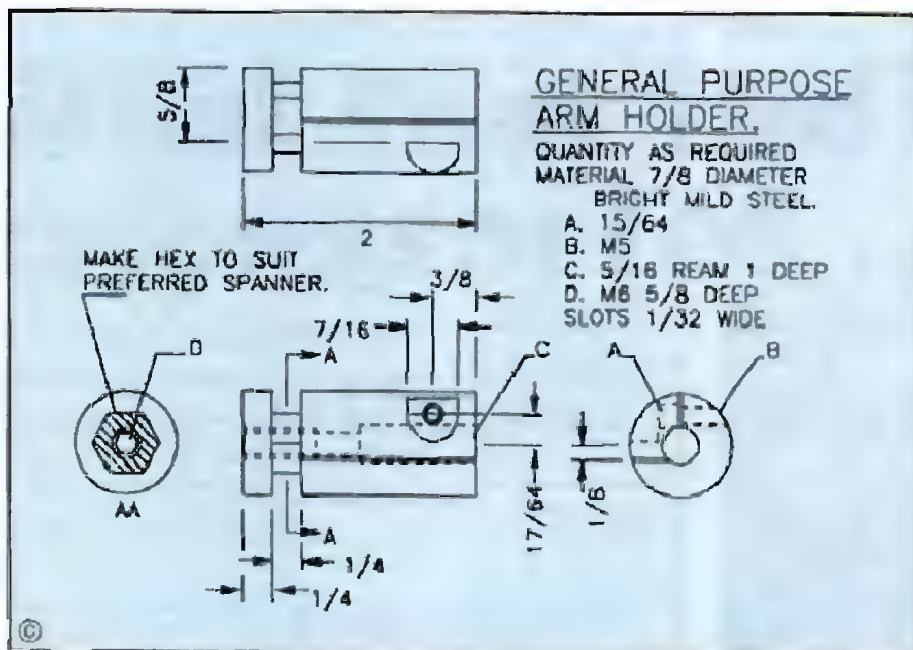
©

5: Method for making the clamp screw and end pad captive.



mounted on the milling table as in photograph 3, machine as shown using a 1/16 in. slot drill to produce three parts, this can best be seen in photograph 4. The small part is for the Vee block; the L shaped part for an inside attachment will be detailed later in the series. Machine round the inside of the L shaped part followed by machining the inside of the clamp body. With this sequence the parts will remain as one until the final cut is taken. When separated, the individual parts will benefit visually if lightly machined again over the already machined surfaces. This additional machining will make the parts a little under size as compared to the dimensions on the drawings, but the dimensions are not that critical.

Very little requires to be explained with



item to put on my list of future projects.

General purpose arm holder

The next item is the general purpose arm holder, this can find uses in many situations, at this stage, mounting it onto a machine table using a Tee bolt will be considered. The item is almost identical to the holder mounted on the milling machine and detailed in the last issue. The item can be seen in **photograph 7**, and with its purpose made Tee bolts and washer in **photograph 8**.

The unit is taller than that fitted on the milling machine, this permits the slot to be longer and is therefore more flexible. As a result it is easier to clamp onto the arm, requiring less torque applied to the clamping screw. The only other difference is, that as it will be fitted and removed frequently, the single flat has been replaced by a complete hexagon. This arrangement being better for applying a spanner when fitting and removing.

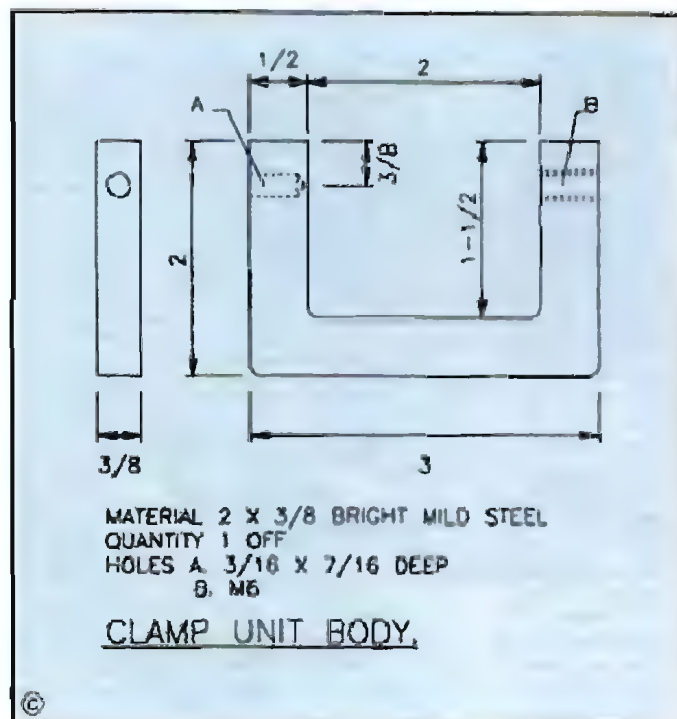
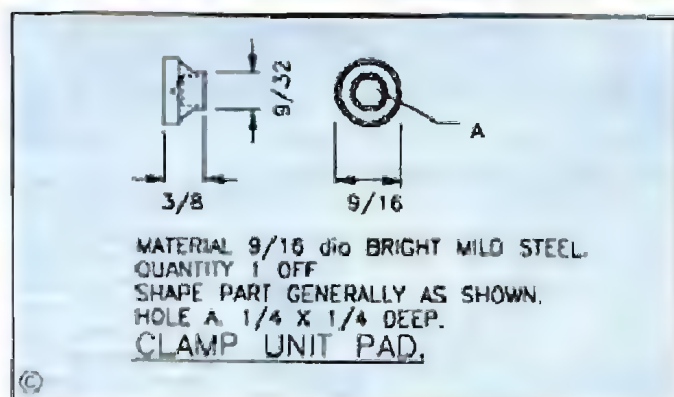
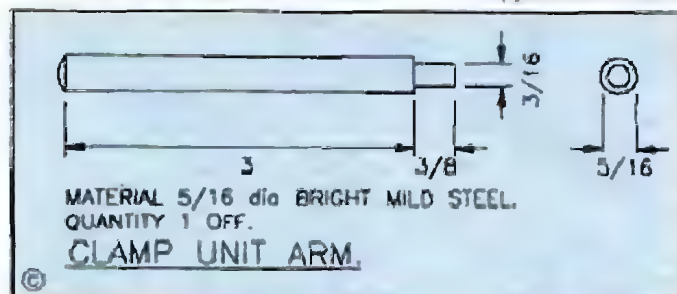
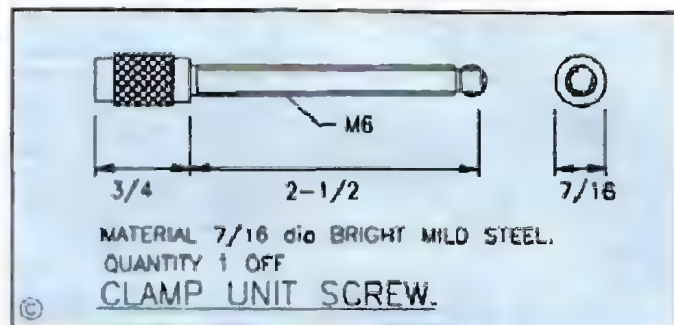
Making the item is identical to that described in the last issue, except for the hexagon which is worthy of mention. Make the part as far as can be achieved on the lathe, now proceed to make the hexagon. Do this prior to slotting as after slotting the part will be less secure when held in the vice. If some form of dividing/rotary table is available this operation will be

regard to the remainder of the clamp assembly as most is straightforward. The ball on the end of the clamp unit screw is not at all critical. Make a slight groove with a parting off tool then produce a rough ball shape using a small file. **Photograph 5** shows an adequate method of closing the pad onto the screw, the photograph is not of the actual screw for the clamp, so do not let this confuse you. The arm, if being made fixed as per the drawings, can be fitted using a suitable two part resin adhesive.

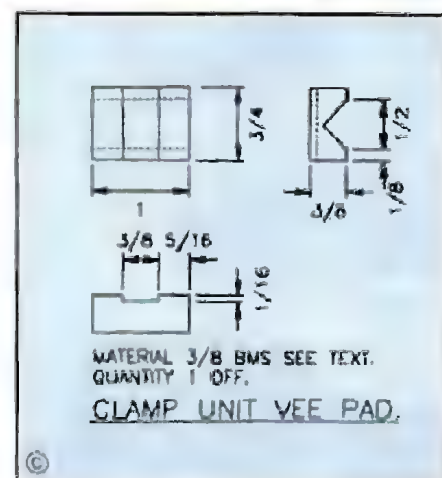
To make the Vee block first machine

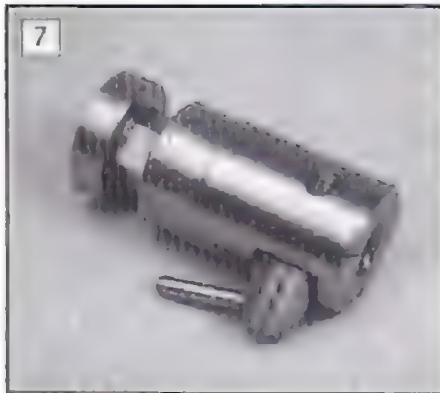
around the four edges to clean up the already machined surfaces, followed by making the 1/16 wide groove to locate onto the clamp. For maximum rigidity when being used, this groove should be a close fit on the width of the clamp body. If a tilting vice is available set this to 45 deg. and machine the Vee as shown in **photograph 6**.

This little Vee block has already proved very useful for applications outside



its original purpose, particularly when clamping round items in the vice for machining. An example of this can be seen in **photograph 17**. Because of this it has been decided that a range of blocks, in pairs, and in varying sizes, would be a useful addition to the workshop. This makes yet another





straightforward, otherwise, the method adopted in this article will be both easy, and produce an adequate result.

Run an M6 hex head screw into the hole in the base of the holder and lightly tighten. Place the holder in the vice on the machine table and align the screw as shown in **photograph 9**. Doing this by eye and using a long rule will be adequate for the purpose. Calculate the depth of cut required to suit the spanner size chosen and machine as in **photograph 10**. Turn the holder through 60 deg., position again using the head of the screw and rule. Do also position the base of the holder level

6: The final stage of making the Vee block.
7: The general purpose arm holder. It can just be seen that it has been returned to the lathe, after machining the hexagon, to machine the inner faces of this area. This together with a slight chamfer (also just visible) improves appearance.

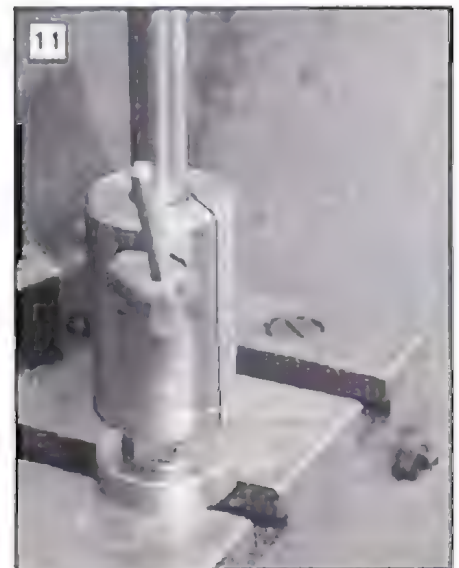
8: The general purpose arm holder and Tee

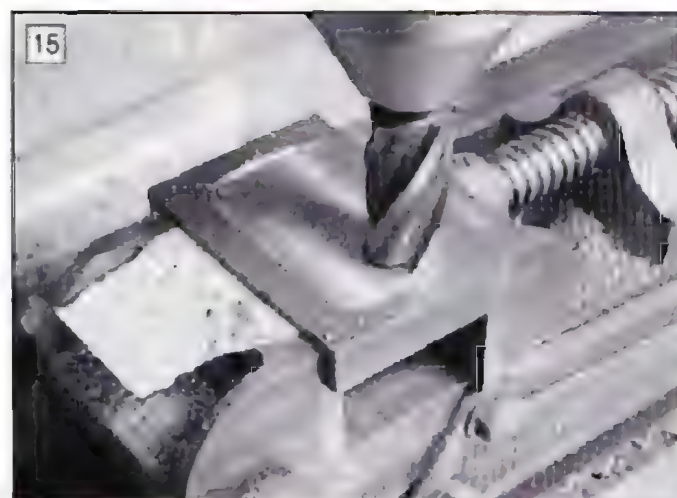
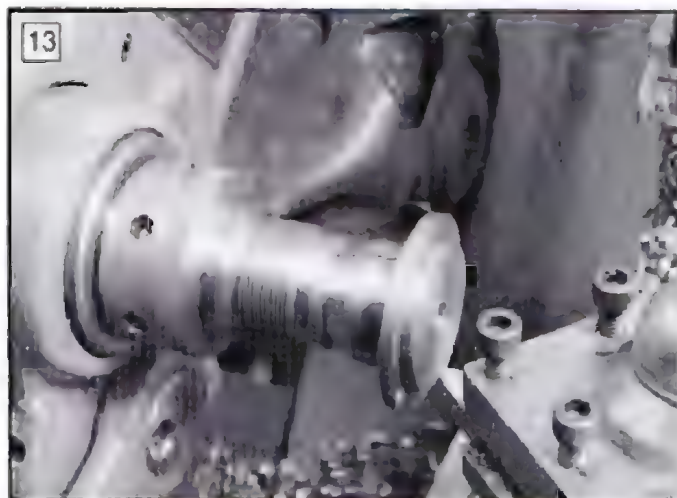
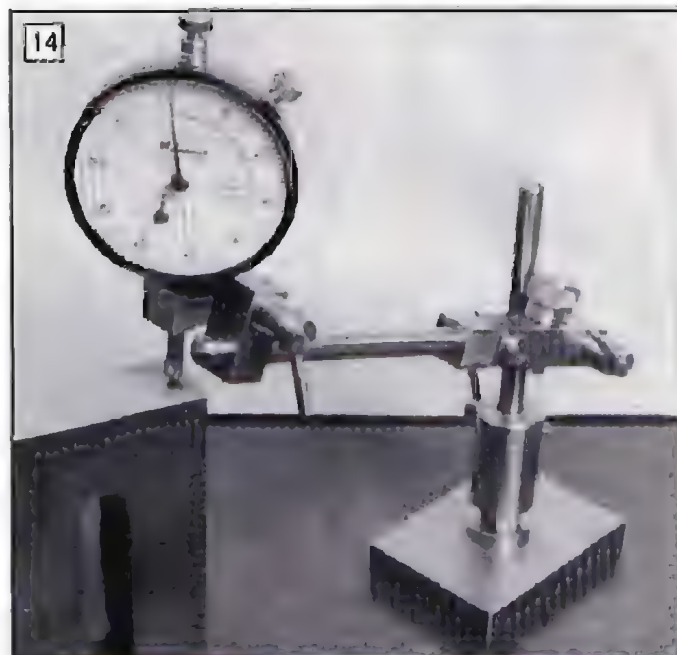
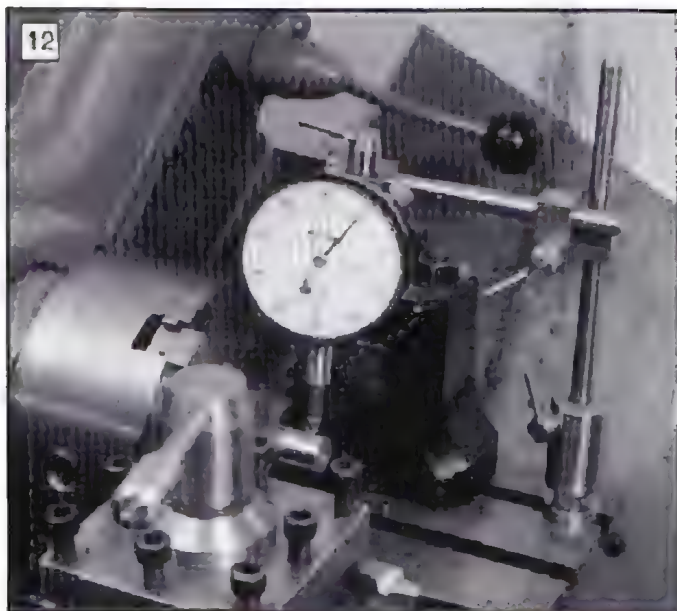
bolts.

9: Using a hexagon head screw to position the general purpose arm holder for machining the hexagon.

10: Machining the hexagon on the general purpose arm holder.

11: The general purpose arm holder mounted to a machine table.





with the end of the vice jaw each time. A washer, larger in diameter than the holder, placed under the head of the screw would make it easy to ensure this position is achieved each time.

Photograph 11 shows the completed holder in close-up whilst mounted to a lathe cross slide, with **photograph 12** depicting a typical application. For mounting the holder on to machine tables suitable Tee bolts will be required, these are shown in the drawings and require no explanation as to how they should be made. A large washer will also be required, for placing under the holder when used on machine tables with wide slots. **Photograph 12** shows the washer being faced using a thin piece of collet. (See article in the Dec '91/Jan '92 issue Ed.)

Base

To further extend the uses of this set, a base can be made to enable the attachments to be used in the free standing mode. A typical example of this, is of a D.T.I. being used on the surface plate, (**photograph 14**). The base has a slightly relieved bottom to aid the proper seating onto the surface plate, this operation is seen being carried out in **photograph 15**. If desired, the bottom of the base could be hand scraped to further improve its accuracy.

Experience gained has shown this base

12: Using the general purpose arm holder to mount a D.T.I. on a lathe.

13: Facing a large washer using a thin piece collet.

14: Assembled with the base to create a free standing D.T.I. mounting arrangement.

15: Relieving the bottom of the base.

16: The two toolmakers type clamps with spigots for mounting on to other accessories, typically the arm clamps also shown.

to be of considerable use and a typical example can be seen in **photograph 20**, later in the article. However it has been found that a much heavier base would be preferable for some applications and I would thoroughly recommend this as an additional component. This could be achieved by the use of thicker material, probably also a larger base area. (Perhaps the cast D.T.I. base, part number 523, from The College Engineering Supply, tel 09074 2284 - Ed.)

Other uses

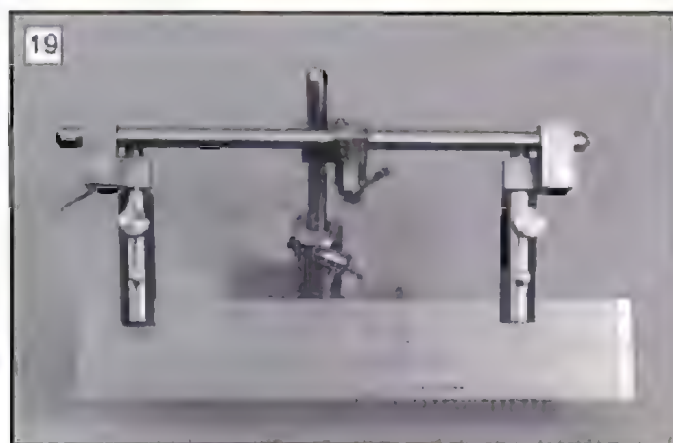
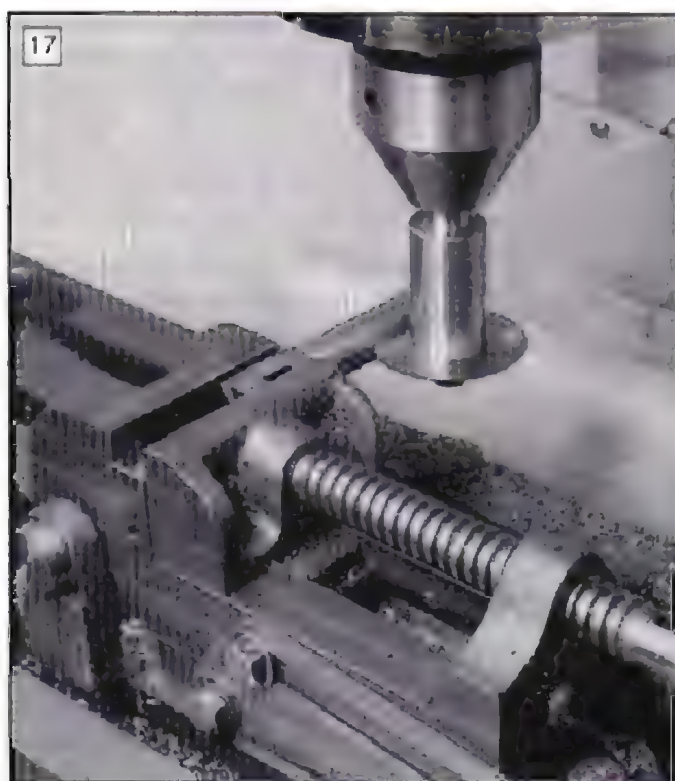
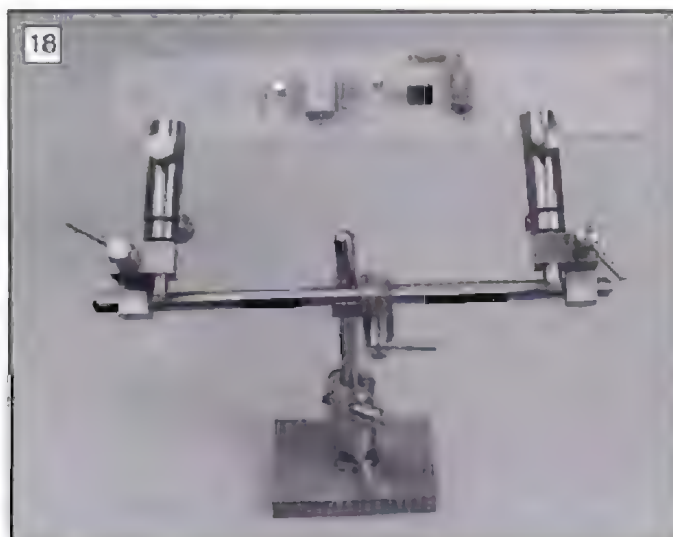
The examples thus far have in the main related to ways and means of mounting the D.T.I. onto the workshop machines or, free standing on the surface plate. Also a possibility but not illustrated in the article is to use the system to position coolant nozzles or perhaps a simple drip feed coolant system. Another possibility, not

illustrated, is the addition of a simple scriber to make a simple surface gauge. This could be with or without, using the fine adjustment assembly.

Without doubt the one item (you may design others, I would like to hear about them, Ed) which has expanded the use of the system substantially, are the two clamps shown in **photograph 16**. These take the form of a small toolmakers' clamp but with a $\frac{1}{8}$ in. diameter extension at the non-workpiece end. The inclusion of these extensions permit their mounting into the various clamps and holders already made and in use.

First produce the part on the lathe, which really consists only of making the $\frac{1}{8}$ in. dia. spigot. With this done and the work transferred to the milling machine, slot along the length on the clamp as shown in **photograph 17**. Close examination on this photograph will show that the small end of the clamp is being held, assisted by the small vee block already made. This illustrates earlier comments regarding the usefulness of these items, going beyond that originally intended.

Before making the final cut to separate the clamp into two parts, drill the holes to the sizes initially detailed. The slot having been cut thus far will help determine the depth to drill, but still being in one piece alignment will be assured. With care the final cut to separate the two parts can be made using a hack saw.



17: Storing the toolmakers clamps. Note the use of the small Vee block to assist with holding the part securely.
18/19: Set up as a heavy duty Helping Hand to assist in printed circuit board assembly.
20: Being used as a mini vice.

The two parts can now be drilled and tapped to their final requirements, with the addition of the clamp screws (no explanation of manufacture required) the clamps are complete. They will, in addition to being used as required by this set of accessories, no doubt find use as normal toolmakers clamps elsewhere. With the clamps made, their usefulness within the system can be explored.

A heavy duty Helping Hand

Most readers, I am sure, will be familiar with the light duty Helping Hands tools which have been available for many years. These have been available through many

these clips will have been insufficiently strong for all but the lightest operations. One advantage they do have though, is that due to their minimal bulk, they have very little tendency to cool parts being held for soldering. They are therefore ideal for soldering small components.

The assembly proposed here follows very closely to the principles of the commercial units, but is considerably more robust and therefore capable of much heavier work.

A good example of this is seen in photographs 18 and 19. In the first, the assembly is being used to hold a piece of strip board to have the required electronic components fitted. With the components fitted and the leads slightly bent to make them captive, the board can be rotated as in photograph 19 to permit the leads to be soldered. Anyone doing this type of work will find this extremely useful, the ability to alter the angle to best suit the soldering position being particularly beneficial.



A mini vice

With base, holder and clamp assembled, as seen in photograph 20, a useful mini vice can be created. This has the added benefit that for small items the part is raised, resulting in it being easier to see than at the lower level of the bench vice. Again there are possibilities for expanding



this a magnifying glass from a commercial Helping Hand is being used, it should not though be difficult to adapt any available lens. The photograph shows a free standing unit, it could just as easily be mounted on to a lathe when carrying out minute work. Providing the work was being carried out dry the glass should remain clean and usable.

Machining shroud

Few machines are supplied with guards when intended for use in the home machine shop and this is not the place to discuss the merits or otherwise of this situation. But guards really perform two functions, one to protect the person from the machine and secondly to protect the person from the product of the machine, i.e. the swarf.

In the first case the guards have to be

on the milling machine using a fly cutter, which results in swarf flying around. At best this will be unpleasant, whilst at worst it could, if proper care is not taken, lead to injuries – in extreme cases perhaps the loss of the sight in an eye.

All that is required to complete the shroud is a piece of clear plastic, say about 8 in. x 10 inches. This can be held using either one or two of the clamps.

photograph 22 shows a shroud mounted on a milling machine. Also, this is the only photograph which shows the holder mounted onto the machine table and using the large size washer.

In this arrangement the shroud will move with the table, which for large parts may not be ideal. As an alternative, the shroud could be anchored to the machine using the holder permanently fitted at the bottom of the down feed stop bar. This holder can also be seen in the photograph.

Photograph 23 shows a typical method of mounting a shroud onto the lathe.

Drawing carrier

Another application for the system would be to use it as a drawing holder. This could be done in an identical manner to that for the shroud, in fact, if the drawing is sandwiched between two pieces of clear plastic, they would also serve to keep the drawing clean.

Dial test indicator inside adaptor

This completes the bulk of the design for this Dial Test Indicator accessory set/helping hand/shroud carrier etc, etc. No doubt readers will find possibilities for its use, other than those included in this article.



this idea. Typically with a longer base, drilled with a series of holes and with two holders and two clamps, larger items could be held. With the clamps being able to rotate the parts need not be straight. Two separate parts could also be held for soldering as yet another use, the possibilities are almost endless.

Magnifier stand

For intricate work, a magnifier stand could be created as in **photograph 21**. in

robust and, in the case of the milling machine, adaptable, so as to permit the many operating modes of the machine to be possible. As a result they can become very inconvenient for one off type production.

In no way do the shrouds suggested here perform this first objective, but if large enough will go a long way to providing first line defence against the second. Safety glasses should still be used to protect the eyes. Many readers will have machined hard brass on the lathe, or most materials



21: Holding a magnifying glass to assist with intricate work.

22: Mounting a shroud on the milling machine.

23: Mounting a shroud on the lathe.

Please send your ideas for other uses to the editor.

There remains just one small item to be described, being the adaptor to enable the DTI to be used for testing obscure locations such as the inside or bores. Details of the design for this will be published in a brief article in the next issue. If you go ahead with making the clamp, do save the small L shape part remaining for making this adaptor.



ELECTRIC MOTORS

- AC

PART 1

In this the first of a series of four articles on the subject of electric motors and their speed control, we consider the AC induction motor both single and three phase. With single to three phase variable frequency inverters now being more economically priced, their use in the home workshop is showing signs of becoming a practical proposition.

Correspondence which comes into the offices of *Model Engineer's Workshop*, indicate a considerable amount of confusion for many readers, when it comes to the application of electric motors. It would be nice to be able to write an article on the subject and to clear up this confusion. This however, would be wishful thinking, not least because of the home machinists desire to use motors salvaged from many differing sources, but at least an effort can be made to improve the situation.

The main problem with matters electrical is described in that well known saying "A little knowledge can be a dangerous thing". If this limited knowledge is then applied to motors of uncertain characteristics and origin, considerable confusion and, more important, possible danger can result.

In an article such as this, it is necessary to avoid giving those without background electrical understanding a false level of confidence. It is true to say that most readers of this magazine will at some time, wish to create some piece of equipment which is driven by an electric motor. Many, I believe, will be deterred by lack of understanding of choosing and using suitable electric motors; hopefully this series will help to improve that understanding.

The purpose of this article is to primarily explain the application of the more common types of motors, it is not intended to encourage the use of uncertain motors from scrap domestic or industrial equipment by all readers. That is not to say, this is an unacceptable practice for those who have sufficient electrical knowledge to use such a motor with confidence. It is possible however, that the article will help bridge the knowledge gap for some, thus giving them the understanding to use motors salvaged from various sources.

For the purposes of this article, it is assumed that any new or second hand motor being considered for use, is fitted with a manufacturers nameplate. This

Photo 1: A computer simulation of a modern motor.

should contain the full technical data, sufficient to apply the motor, or failing this, at least the makers name and type/serial number, so that the maker can be contacted for details. It would be foolish to attempt to use a motor, not marked with sufficient information to fully appreciate its characteristics. When a motor is to be purchased, this article will assist in obtaining the best item for the job, by indicating the information that will require to be conveyed to the supplier.



The basic motor

It will come as no surprise that a motor consists of two major assemblies, the fixed, and the rotating. The terms used for these are normally stator and rotor for AC induction motors and, field and armature for commutator type motors, both AC and DC. The terms stator and rotor are self explanatory, but for the other terms, field

refers to the static component, and armature to the rotating component.

In very basic terms, motors work by both parts having their own magnetic field, these either attract or repel each other thereby causing rotation. How this rotation is maintained, and not just locked into a fixed position as would two magnets, is beyond the scope of this article. How these

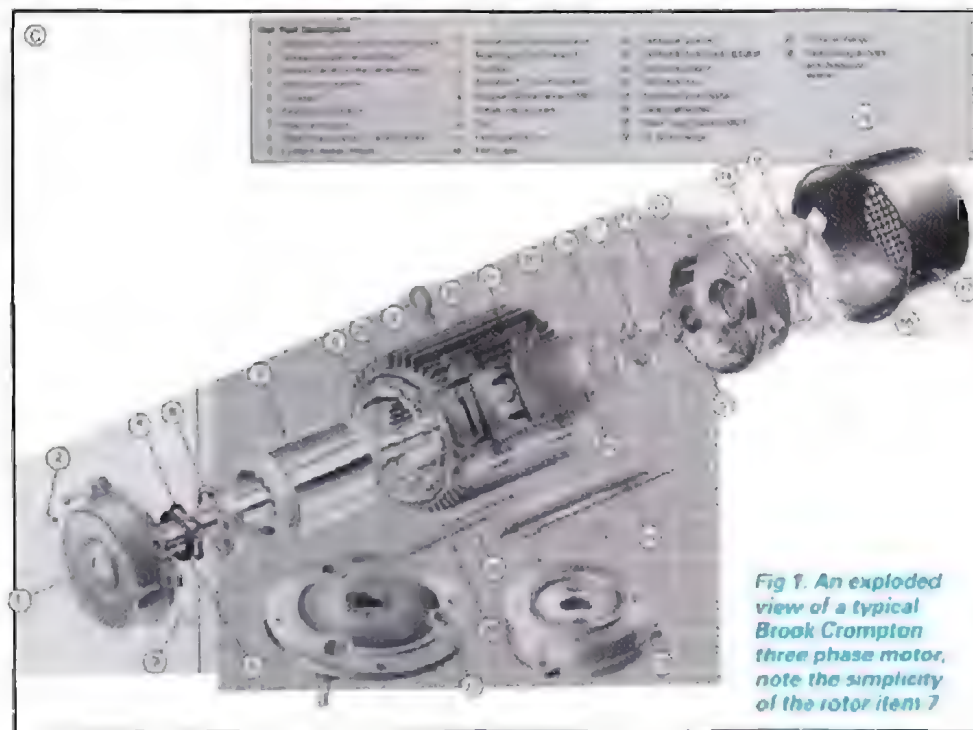


Fig 1. An exploded view of a typical Brook Crompton three phase motor, note the simplicity of the rotor items 7

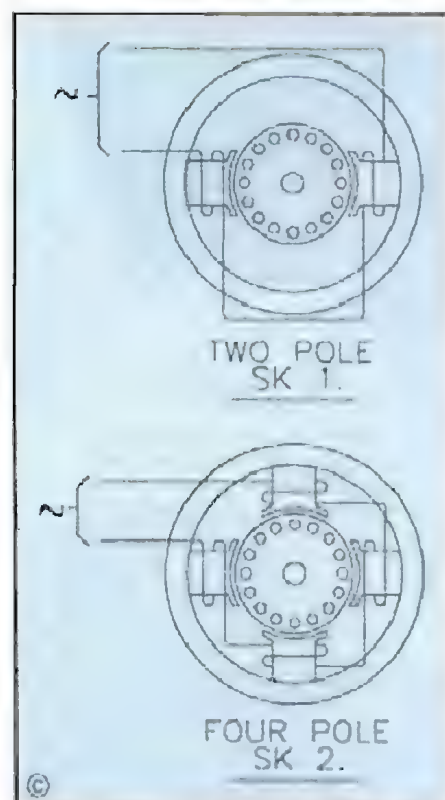
magnetic fields are achieved will depend on the type of motor and in particular whether intended for AC or DC use.

The induction motor

This is a motor for use on AC supplies, and is the type almost always used to drive fixed speed machines in the home workshop. Its popularity is due mainly to its inherent simplicity, this being particularly so for three phase motors. This simplicity has a marked effect on cost, where for motors of say 0.5KW and above, a price ratio of 3:1 is probable when compared with similar size DC motors.

The stator is wound to create the magnetic field as shown in **sketches 1** and **2**. **Sketch 1** is known as a two pole machine and **sketch 2** as a four pole machine for obvious reasons, more about that later. These sketches represent single phase motors, three phase motors will have 6 or 12 poles.

Most readers will have seen the type of motor where power is fed to the rotor (armature) from carbon brushes, via a round copper device divided into many



segments, this is known as a commutator. Inspecting the inside of an induction motor will reveal no such item, so how does the rotor receive power to create its own field? Now I consider most readers will be aware that a transformer consists of two windings, the one (primary) connected to the AC supply, the other (secondary) having an output which can be used to power the required devices. These windings are not interconnected and their only link being that of the magnetic field set up by the primary winding.

Now in the case of the rotor of an induction motor, this is wound and sitting in the fluctuating field created by the alternating voltage (AC) applied to the stator winding. If the rotor winding were left with its ends not connected to anything, a voltage would result but no current would flow. This would be like a transformer

without a load connected to its secondary.

To make current flow in the rotor windings, the ends are connected together to form shorted turns. Because of this, current will circulate in the windings and a magnetic field will be established as a result. In practice the rotor is made with copper bars, and the ends connected together, rather in the form of a cage. Hence the term squirrel cage which is frequently applied to this type of motor, especially three phase types.

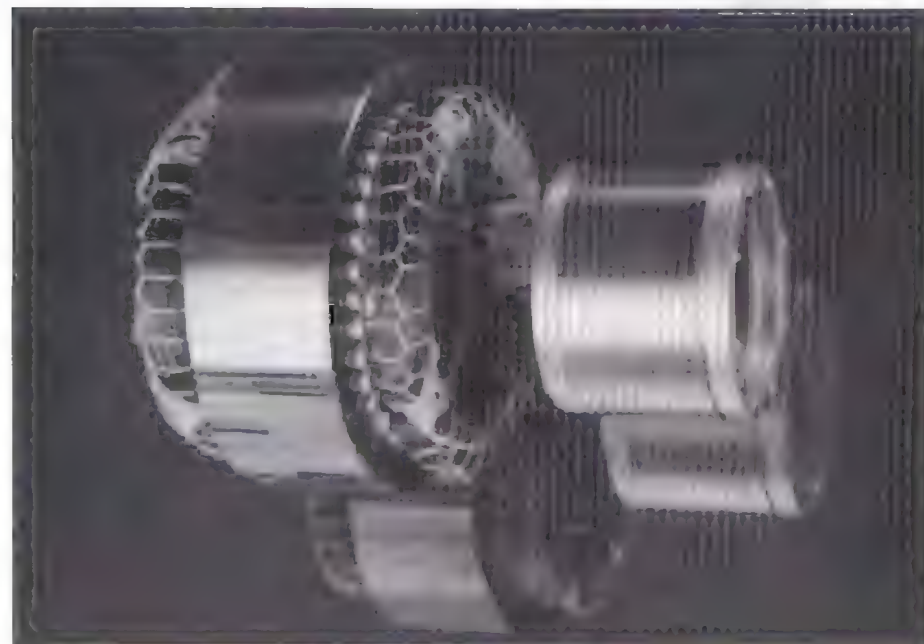
The absence of a commutator and brushes makes this a very reliable motor, provided that it is not overloaded. Present day motors are rated very close to their maximum power output, and therefore temperature, and are very happy to run at this load continuously, without any sacrifice of reliability. This situation however, does mean that they cannot be overloaded by more than a few per cent, the result of a greater overload would be to seriously overheat the windings, causing eventual failure. The time before failure would depend on many factors, typically whether the motor had just been started from cold, or, if it had already been running on normal load for some time, and was therefore already near to maximum temperature. If already up to temperature, the time to failure will be a matter of a few minutes for an overload of say 50%, maybe half an hour if only 10%. Because of this situation, suppliers of induction motors will make a condition of their guarantee that a suitable electrical overload is connected in circuit. (see article on motor starters in the April/May '91 issue of *Model Engineers' Workshop* Ed).

With the essential overload device (correctly chosen and set) in circuit to protect against overloads, the only other possible cause of long term failure are the bearings. It therefore becomes a very reliable item of equipment.

Single phase induction motors

Reliability referred to above applies to the induction motor in its three phase form. In the case of the single phase version an additional winding, fed via a capacitor and centrifugal switch, is required. The purpose

Photo 2: The two main parts of a three phase motor, showing the simple construction of the rotor.



of this is to start the motor rotating, for without this the single phase motor is not self starting.

Once started, this winding, which is also on the stator, is normally switched out of circuit by means of the centrifugal switch mounted on the rotor. This arrangement makes the single phase motor both more complex and more expensive than a similar power three phase motor. The extra complication also makes it less reliable. Even so it is still more reliable and much less costly than DC commutator motors.

Motor speed

Having established how the two fields are created, it is beyond the scope of this article to explain how this is translated into continuous rotation. Even so, one feature is worth knowing, even though it may not be fully understood to how it is achieved. If it is considered that a 50 cycle per second AC supply can also be referred to as a 3000 cycle per minute, this can be related to the speed in terms of revolutions per minute for a two pole motor. In the case of a four pole machine, for each cycle the rotor will still only pass two poles, which will therefore give a speed of 1500 revolutions per minute. It is for this reason that the slower motor is the more expensive, as it requires to be constructed with two additional poles. Machines with six poles will run at 1000 r.p.m., those with eight poles at 750 r.p.m.

Readers with experience in choosing AC motors will be saying that the figures quoted are incorrect, and so they are. For the required transformer action between stator and rotor, the rotor must run at a slightly lower speed, than the above speed known as the synchronous speed. The difference in speed being known as the slip speed. The probable speeds will be in the order of 2900RPM and 1450RPM. These are essentially fixed, and will only vary by a few RPM from no load to full load conditions. This characteristic makes this type of motor ideal for driving machines with intermittent loads, typically lathes or milling machines. One characteristic of this type of motor is, that if overloaded beyond a given value, the motor will quite suddenly stall due to its essentially constant speed characteristic.

Many readers will consider it probable, that to reduce the speed of the motor all

that will be required, will be to reduce the applied voltage. This is not the case, and the motor will continue to run at or near synchronous speed. The effect of reducing voltage will be to reduce output power available, and will therefore lower the load at which the motor will stall. This characteristic can be put to good use in certain situations, as was discussed quite recently in the article *Talk about Torque* in *Model Engineer* Vol 187 page 314.

Speed variation of this type of motor can only be achieved by the addition of very expensive power inverters having a variable frequency output. Even so like most electronic equipment, they are much less expensive than in the past. Even with these they are only easily applied to three phase motors. The reason being that due to the centrifugal switch on single phase motors, the starting windings would be switched back in when the speed was reduced. These systems will permit both increase and decrease of speed, typically

confused with the now common, single to three phase convertor, which is still a fixed frequency device.

Two speed motors can be obtained with terminals from the stator windings available, which permit switching between two and four pole, that is 2900rpm and 1450rpm they are of course more expensive than single speed machines.

Other single phase motors

The earlier comments, whilst appropriate to many forms of single phase induction motor, have been made with the most frequently used capacitor start motor expressly in mind. Other types of single phase motor are available, but as they are found only rarely, they are not included in this article as they will only add unnecessary complication.

Typical names for these alternative motors are Split Phase Motors, Capacitor Run Motors, Capacitor Start/Capacitor Run Motors and Shaded Pole Motors. Details of

difference being that in the latter case some form of control switch will be required, whilst for the once only change, it will be a case of making changes to the connections at the motor terminals only.

It is rarely likely to be an acceptable practice to reverse a motor whilst running from the point of view of the mechanics involved. Whilst it can be done in a few cases electrically, and then only with three phase motors, this is beyond the scope of this article. Any reader wishing to reverse a motor whilst running who is uncertain of the situation, should seek expert advice, at least by reading an authoritative book on the subject.

Reversing a three phase motor is very simple electrically, it only being required to reverse any two connections at the motor terminals. For the capacitor start single phase motor it is necessary to reverse either of the two windings, leaving the other untouched. If the start winding is being reversed, this is the one which also has the capacitor in series with it, only the winding can be reversed. Alternatively, if easier, the capacitor can be left connected to the winding and the two reversed as a pair. It does not matter to which end of the starting winding the capacitor is connected.

The method of making it possible to reverse a motor frequently, will be either by a manual switch or by a complete reversing starter. To totally eliminate the possibility of reversing a motor whilst still on the run will involve quite complex controls. These will use timers to ensure the motor has had time to come to rest, or speed sensing switches to actually test that the motor has stopped fully before restarting. This level of complexity would rarely be warranted in the home workshop and some more economical approach is desirable. The essential feature of any less foolproof systems would be that at least two operations should be required to complete a motor reversal.

Without doubt the best compromise is for the motor to be started and stopped using a no volt release direct on line starter. This is one which includes a contactor to switch the motor and requires the start button to be pressed again on

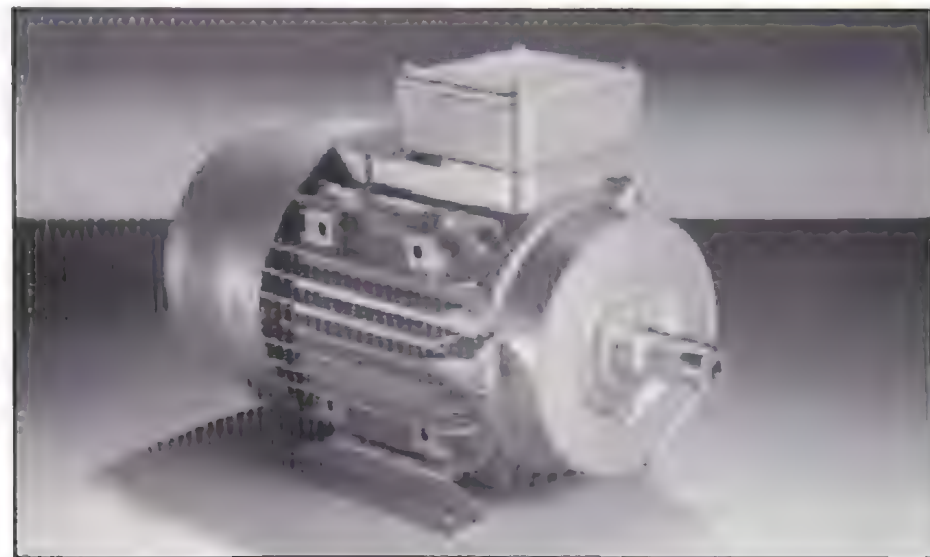


Photo 3: A modern Brook Crompton aluminium frame motor having multi mount facilities. These are available from 0.07KW up to 37KW three phase. Similar single phase motors are available but covering only the lower end of the power range.

300rpm to 3000rpm with a 1450 rpm motor. Another factor to be considered, is that many motors are partially cooled using a fan mounted on the motor spindle. As a result, the effect of reducing the speed is to greatly reduce the cooling effect of this fan, and thereby the permitted output torque at the lower speeds.

It is unfortunately not possible to be very specific regarding this reduced output, but reductions to 60% over a total 10:1 speed range and, to 50% over 25:1 are typical. It should be noted that the overload protection, using the normal thermal overload provided with a direct on line starter, will be non-effective at the lower speeds, so great care must be taken. Some of the more complex variable frequency inverters, mentioned below, will have a ramp function, output current limit. This will reduce the possibility of motor burn out at lower speeds; more about that in the third part of this series.

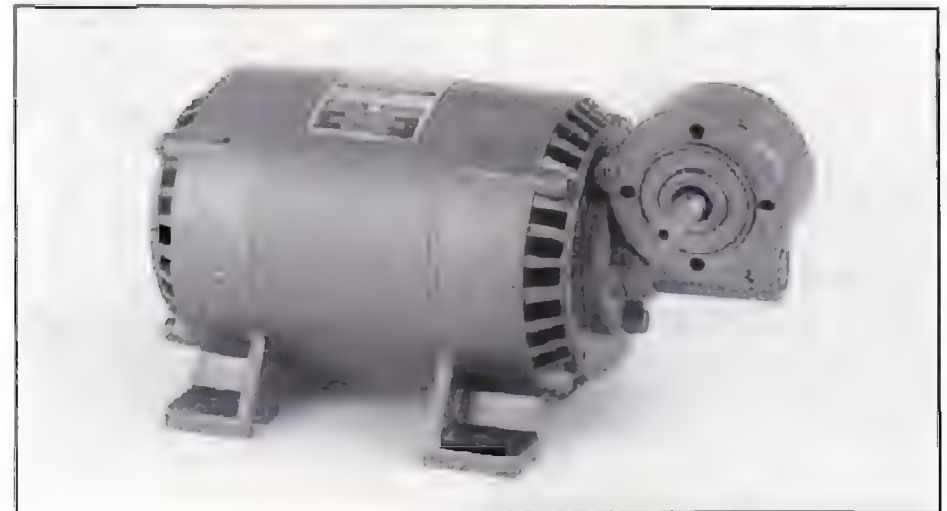
Single phase input to three phase variable frequency output inverters are available, and these will achieve variable speed with a three phase motor from a single phase supply. This should not be

these motors together with greater technical detail for all motors discussed in this article can be found in the Argus Specialist Publications book *Electric Motors* by Jim Cox.

Reversing induction motors

Reversing a motor can be a requirement, either to achieve the correct rotation when first installed, or to be able to frequently reverse the motor, to suit the operation being carried out at the time. The changes required will be the same whether its a first time only or a frequent requirement. The

Photo 4: A small Parnalux motor with output gearbox, available for single or three phase supply. Output power is up to 120W, speed is either 1400 or 2800 rpm without a gearbox. Speeds from 35 up to 680 rpm are available with differing gearboxes. This is typical of the very wide range of small AC and DC motors supplied by this company.



power failure. To reverse the motor, a manually operated switch is required to make the required changes to the motor connections, and this switch would have three positions, Forward, Off and Reverse. In addition to the contacts wired into the motor circuits there would be a further contact, open only in the off position, and wired into the starter stop circuit. Thus when moving the switch from forward to reverse the starter would switch off as the switch passed through the off position, it would be necessary to press the start push button to re-start the motor, this I consider is adequately fool-proof.

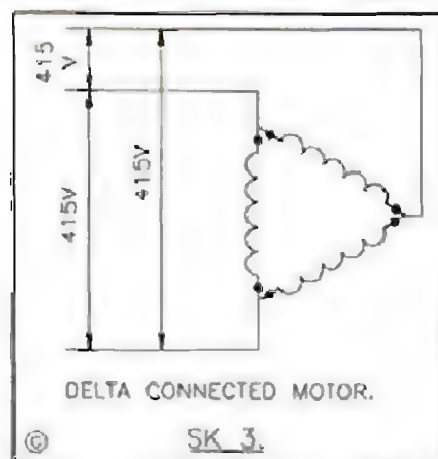
Three phase motors star-delta connections

Whilst discussing methods of connecting motors to their power supply, it is appropriate also to consider the effect of star and delta connection. To do this, it is worth recapping, and expand a little, on the information given in the three phase article published in the Feb/Mar Issue of MEW.

In the U.K., almost all three phase supplies will have a phase to phase voltage of 415V. In this case, the phase to neutral voltage will be 240v (phase voltage $\times \frac{1}{\sqrt{3}}$, i.e. $415 \times 0.577 = 240$). Earlier in this article it was stated that a three phase motor would have 3 stator windings, these would be connected either as in sketch 3 or sketch 4. The term for these methods are, delta (sketch 3) and, star (sketch 4), for obvious reasons.

In neither of these circuits is the neutral connection shown connected, and in the case of the delta connected motor (sk.3) there is no terminal to which is could be connected. In the case of sk.4 there is a star point, (the junction of the three windings) but even here, nothing is gained in connecting this to the neutral line.

Considering first the delta connection. It can be seen that each individual winding is connected directly line to line, they therefore each see 415v. This is not so in the case of the star connected arrangement, and whilst not connected to



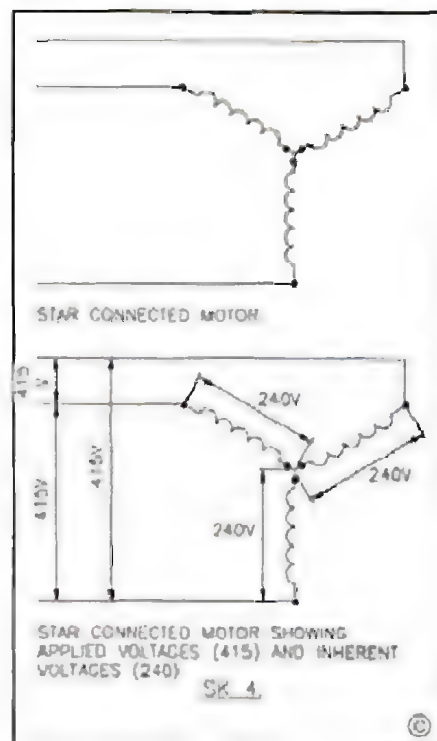
the neutral line, the star point will be at a potential of 240v with respect to each line, exactly as is the case with the three phase and neutral supply.

From this it should be obvious that the windings of the delta motor are wound to expect 415v, and the star motor to expect 240v. As a result, under normal circumstances, it is not permitted to change a motor from one method of connection to the other. If a star connected motor with its

240v windings were connected in delta to a normal UK supply of 415v, the windings would see an excessive voltage. On the other hand, if a motor intended for delta connection was star connected, each winding would only see 240v instead of the required 415v.

There are though two instances where the above rules are not followed, as a result, motors are frequently supplied with six terminals, even though the motor is intended to be run continuously in one configuration only.

The reason for permitting a delta connected motor to run in star, primarily an industrial requirement, is to limit starting current and then only applicable to larger



motors, say 10KW plus. In this case all six leads are connected individually to a special starter. This initially configures the motor in star, thus each 415v winding will see only 240v, and as a result will limit its starting current. When the motor has been running for a few seconds and is partially up to speed, the starter will reconnect it in its normal delta form for continuous running.

This is rarely likely to be a requirement in the home workshop, unless it is situated in some remote area. In this case the electricity supply company may make this a requirement, even for quite small motors. This will help to avoid a large voltage drop, due to the large starting current, and the length of cables supplying remote electricity users.

One bonus of the requirement for six terminals, is that a 415v delta connected motor can be run on a 240v supply if star connected. In the past this would have served no purpose, (except maybe using a motor intended for use in another country say a U.K. motor in the U.S.) but some modern single phase to three phase variable frequency inverters for low power motors, do only have a low voltage output. These require, either a special low voltage motor or, a delta connected 415v motor connected in star. Unfortunately not all small motors have six terminals, so it will be necessary to check this point before

spending money on an inverter for an existing motor.

One added advantage of these inverters is that they can initially output a lower voltage, this will limit starting current thus achieving the same effect as the star/delta starter. In this case it is called a soft start feature, more will be said about this in the third part of this series. This will deal with the facilities available in such variable frequency drive equipment and how to choose a suitable unit.

The above values indicated, are those found in the U.K. Whilst in other countries the supply voltages will differ, the factor of ($\frac{1}{\sqrt{3}}$) between delta and star voltages will still be appropriate. Motors do have some latitude as to the value of the voltage applied to them, and the values of 415v and 240v can tolerate some variation. In fact, as stated in the above mentioned M.E. article reduction of the supply voltage will just reduce the maximum output power and stall torque. Modern motors are frequently sold as being for 380/420v delta connected and 220/240v star so as to maximise the potential use for standard motors.

Commutator motors

This is a general term for a range of essentially similar motors, but, having variations so as to achieve a wide range of motor characteristics. In this case the motor has power fed to the stator in the same manner as that for the AC induction motor. Though the stationary section of the motor is referred to as the field in this case.

The rotating part is called the armature and has power fed to it from the power supply via the brushes and the commutator. The armature is therefore powered directly rather than by transformer action as in the case of the induction motor. This makes the commutator motor a two winding, four lead device.

There is no visual difference to the untrained eye between commutator motors for use on AC and those for use on DC. In fact some motors are sold as universal motors for use on either AC or DC. Commutator motors will be covered in much greater detail, albeit with mainly DC operation in mind, in part two of this article being published in the next issue.

Acknowledgements

I would like to acknowledge the help given by Brook Crompton, Huddersfield (0484 422150) for permitting the publication of the exploded view of a three phase motor and also photos 1, 2 and 3, and to Parvalux Electric Motors Ltd of Bournemouth (0202) 512575) for photograph 4.

Copies of the book *Electric Motors* Workshop practice series No.16

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Photocopies of articles previously published and mentioned above can be obtained for £1.50 for U.K. readers and £2.00 overseas readers. Requests should be sent to the Photostat Service, Argus Specialist Publications, Boundary Way, Hemel Hempstead, Herts HP2 7ST.

TRADE COUNTER

A first look at products which may be new to you, plus information on finding difficult items and a few problem items to source.

Portable band-saw

C.Z. Scientific Instruments Ltd are pleased to announce exclusive distribution in the U.K. and Ireland for the latest band-saw from Femi of Bologna. With typical flair, this well-known Italian manufacturer has designed this excellent portable band saw to suit the requirements of both domestic and professional users.

Despite a solid and stable base and a cast-iron vice, the Femi 780 weighs only 18 kg, making it the ideal choice for those whose workshop space is limited and to those who work away from home. Amongst the many attractive features the Femi 780 offers a virtually silent 750 Watt single phase two speed motor, a bi-metallic cobalt saw blade, which needs no lubrication, and a cutting angle adjustable from 0 to 45 degrees. It is a compact machine having dimensions of 680 x 330 x 530mm high. The two blade speeds are 56 and 70 M/min. The cutting capacity is 85mm round and 85 x 105mm rectangular, at 45 deg. these reduce to 75mm and 75mm x 65mm.

For details contact Industrial Equipment Department, C.Z. Scientific Instruments Ltd., PO Box 43, 1, Elstree Way, Borehamwood, Herts. WD6 1NH. Tel: 081 953 1688, Fax: 081-953 9456.



Machine Mart in the South West

Machine Mart have opened their 28th store, this time at Plymouth. They may have "gone west" but this is far from the case in a business sense; the superstore

being their fifth opened this year. Readers in the south will be encouraged by this predominantly Midlands base firm moving south. They do of course offer a very good mail order service, see their advert in this issue.

Sources of supply

I would like to thank the readers who have provided the following information. These are in reply to requests for materials and tool suppliers in previous issues.

Half round brass

J Smith and Sons, (Clerkenwell) Ltd, 42-56 Tottenham Road, London, N.1, tel. 071 253 1277. They list this material in 10 sizes and also have other depots around the country, look in your local yellow pages.

Also available in 5 sizes from Blackgates Engineering, 209 Wakefield Road, Drighlington, Bradford, West Yorkshire, BD11 1EB tel. 0532 853652.

Suppliers of materials

The following two companies have been recommended as suppliers of castings in various materials. They will accept orders for one off's to readers own design, and also supply blocks and bars of cast iron and other materials.

D M Foundries Ltd, Stafford Mill, London Road, Thrupp, Stroud Gloucestershire, GL5 2AZ tel. 1453 763375 Fax 0453 753272

Williams Alexandra Foundry Ltd, Wentloog Road, Rumney, Cardiff, CT3 8YD tel. 0222 777221

Should any reader wish to visit either of these I can supply details of how to get there by road, please send a stamped addressed envelope marked "Foundries"

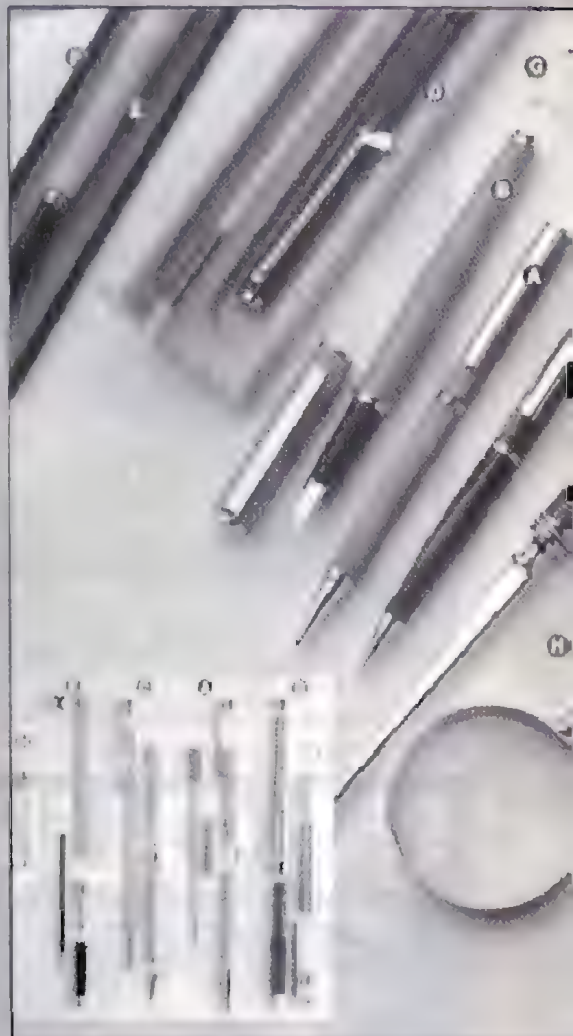
I will be pleased to continue to publish names of similar local suppliers if readers will send in details

Craft supplies

A new catalogue has been issued by Craft Supplies. It is primarily intended for those interested in wood turning, and to a lesser extent carving. It has though, many items of interest to those for which these are not the normal activities.

Why not purchase a few of the various pen and pencil mechanisms, together with suitable wood blanks and produce some up-market pens and pencils. Requiring to be turned on mandrels due to the delicate nature of the wooden tubes, this will be an exercise quite at home on a metal working lathe.

A very wide range of wood species is available in a range of sizes. Machines are also listed together with the usual accessories, but also many accessories for very special applications. The catalogue is particularly interesting for its range of items to complement the woodworking



activity. These are too many to list but typically are, watch and clock inserts from wrist watches to grandfather clock mechanisms, a wide range of round patterned tiles for such items as cheese boards, and many many other items.

Another interesting provision by Craft Supplies are their two day turning courses, these can include accommodation. There are three courses most weeks making around 150 during 1993. These courses range from those for the absolute beginner to those for the very experienced.

The catalogue is price £2.00 and can be obtained from branches of W.H. Smith or from Craft Supplies Ltd, The Mill, Millers Dale, Nr Buxton, Derbyshire, SK17 8SN (tel. 0298 871636, Fax 0298 872263).

QUICK TIP

When working with sheet brass, if work hardening occurs and the material has to be annealed, if the sheet is smeared with ordinary machine oil and then heated with a blow lamp until all the oil evaporates (it is close to the right temperature for quenching). It can then be plunged into clean, cold water and is once again workable. (Very useful when metal spinning).

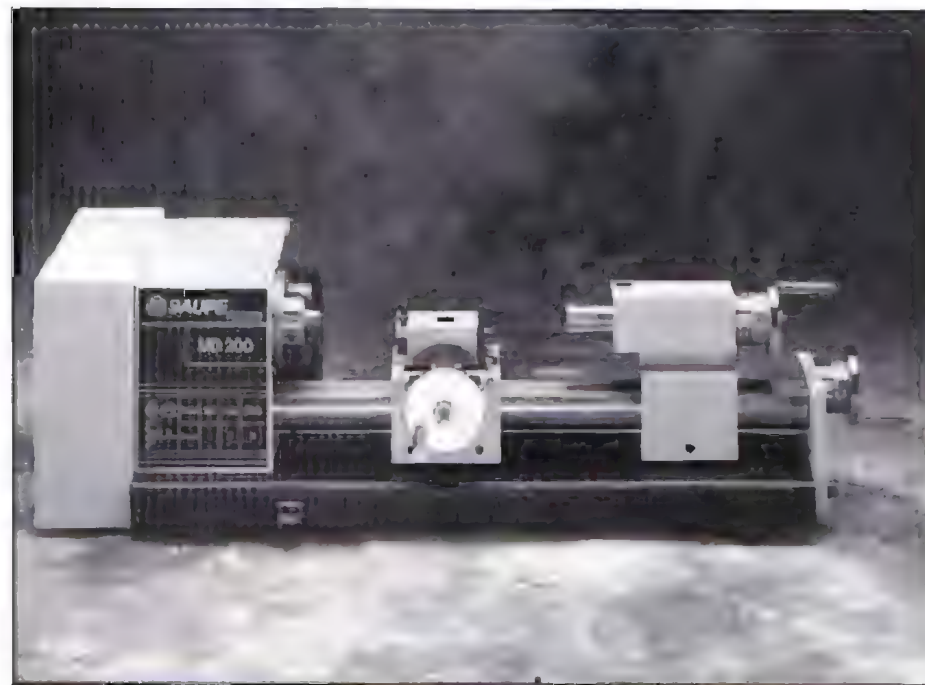
Alan Jeeves

Minitum 200 lathe from C.Z. Scientific

Hobbymat have introduced the Minitum 200 lathe, this is additional to the already popular Hobbymat MD65 and Prazimat DLZ200 lathes. It has similarities, and some common components, to the slightly larger MD65. This comes from the same factory

as the existing lathes and is made to the same high standard.

The basic specification is, maximum turning diameter over bed 100mm, over saddle 40mm, and with a capacity of 200mm between centres. The lathe is fitted with a 120W motor and with speeds, set by stepped pulleys and belt, of 560, 1000 and 2000rpm.



The main spindle has a M14 x 1 thread which is common with other small lathes, it also has a flange with arrangements for fitting attachments with three screws, it has an 8mm bore. The tailstock has a No. 1 Morse taper and a travel of 40mm.

Leadscrew dials for the cross slide and the saddle are calibrated with 0.025mm divisions, the cross slide has a travel of 65mm and the saddle 200mm. There is no top slide fitted but we understand that there is one in development as is also an attachment for obtaining additional speeds.

The footprint is 570mm x 260mm and the weight is 25kg. The lathe would be ideal for anyone requiring a small lathe without screw cutting facilities, its list price being £325.00 + VAT.

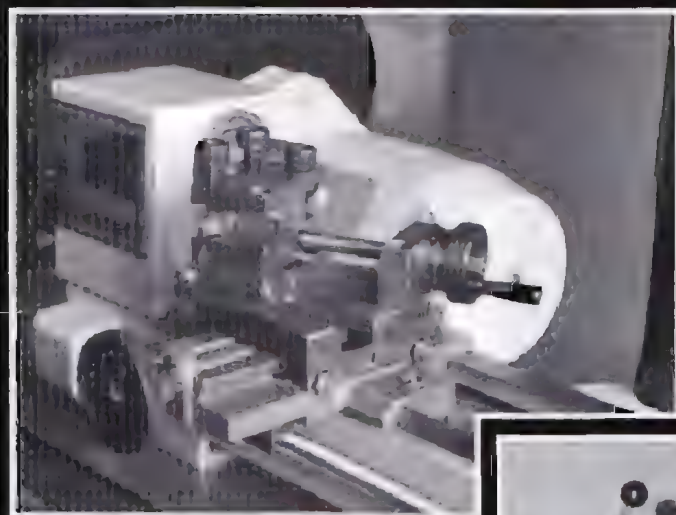
For further details, contact C.Z. Scientific Instruments Ltd, PO Box 43, 1 Elstree Way, Borehamwood, Herts, WD6 1NH. tel. 081 953 1688.



QUICK TIP

Card or paper slip-in labels used in most types of storage boxes and drawers soon get very grubby from oily fingerprints and general grime. Make them instead from white plastic card. From an ice-cream tub, this can be written on with a permanent felt pen and will last for years.

IN OUR NEXT ISSUE!



Coming up in the April/May issue will be:

A tool and cutter grinder. A very useful item and a major constructional project.

A fabricated top slide for a Unimat 3 but adaptable for any other small lathe; even maybe as a mini vertical slide.

Some much sought after information on the theory and application of DC motors.

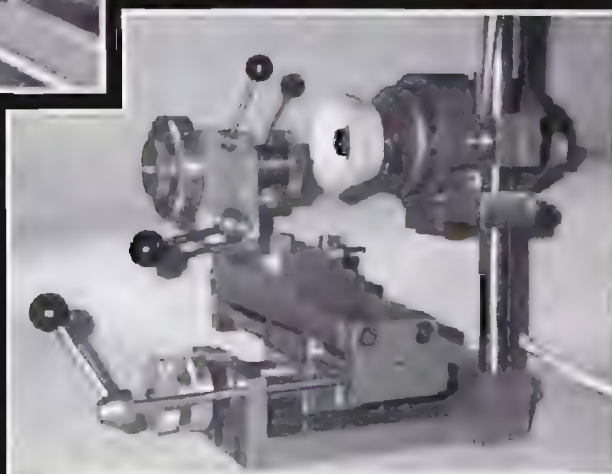
Continuing our series on the history of machines and allied interests. The Evolution of the Lathe continues to trace the various types down to those we use today.

Also some small constructional projects including a Milling jig cum vice.

And much more

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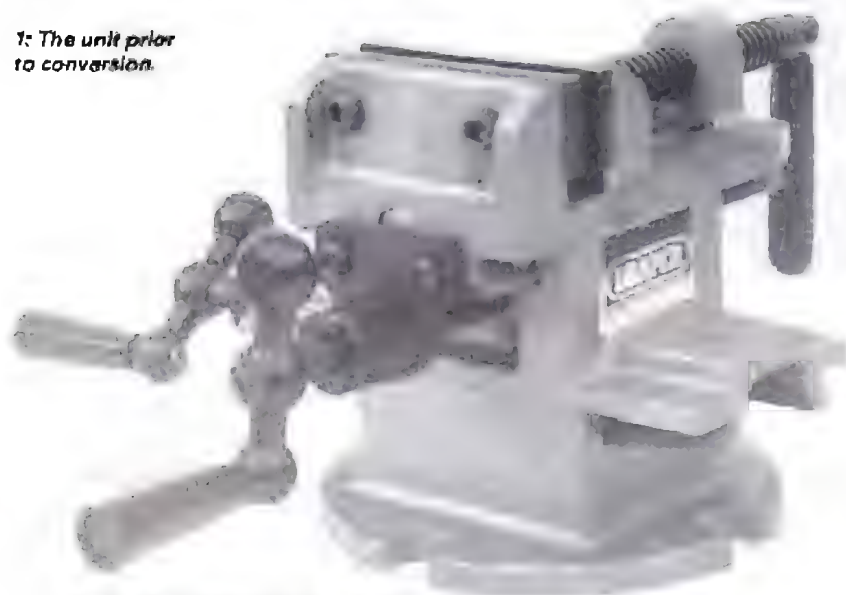
Contents may be changed



Crossvice to Vertical Slide

**PULL OUT
PLAN**

1: The unit prior to conversion.



In the April/May '92 Issue of *MEW* a request was made for an article describing the manufacture of a vertical slide for use on the lathe. Here we publish an approach using one of the widely available cross vices, this has been provided by Mr E. G. Hartwell. Other articles are available as a result of the request and will be included in *MEW* in due course.

Some years ago, in the absence of a milling machine, the writer purchased a 4 in. cross vice of Far Eastern origin for use with a $\frac{1}{2}$ in. bench drill – with only modest results due to the lack of rigidity of the drill spindle and the chuck overhang. Following the purchase of a combined lathe/vertical milling machine this unit was converted to provide a vertical slide for use both on a 6 in. Churchill Cub Lathe and the lathe/mill. Based on experience gained during the above modification, a further smaller 3 in. cross vice has been converted, which should be suitable for use on lathes of 3 in. centre height upwards and which forms the subject of this article.

The work involved includes the cutting of an Acme thread nut, basic workshop techniques and the refitting of the vice slideways, all of which should be within the capability of the owner of the average home workshop. The additional materials required are readily available and, in the writer's case, were offcuts from 'under the

bench'. Detailed information is, however, provided on some aspects which may assist those with limited experience of such work. Due to the wide variety of small lathes currently in use, specific information on the cross slide mounting is not possible, but the suggestions provided should enable this aspect to be achieved without difficulty.

Back to basics

The typical small centre lathe is essentially designed for turning and boring with tools mounted in the tool post, some with the additional facility of a Tee slotted cross slide for boring purposes. The use of such machines for horizontal milling in conjunction with a vertical slide creates forces, some of which are in a upwards direction or outside the saddle support area and, frequently both. It is essential, therefore, that the lathe slideways – the bed and cross slide – are in reasonable condition and adjusted to take up any

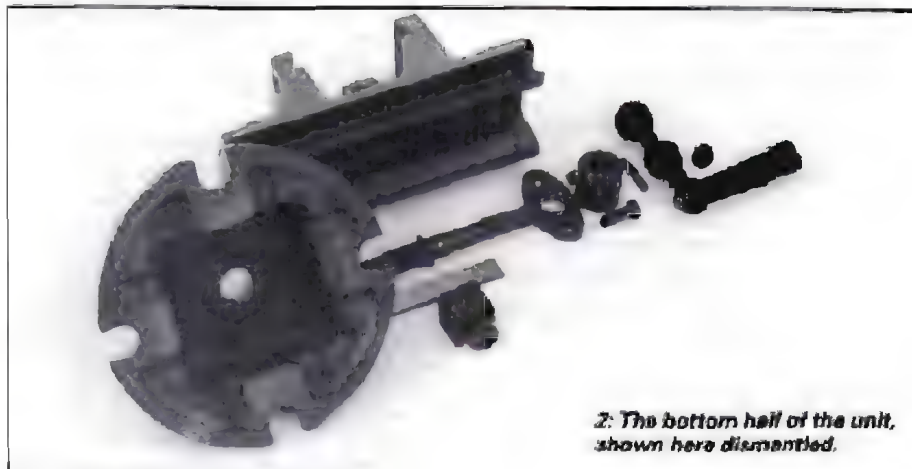
'slack'. The headstock bearing should be similarly be in good condition with no 'lift' but backlash within the feed and lead screws and their nuts is acceptable provided conventional milling techniques are adopted. Climb milling (cutter rotation in a similar direction to the feed) is only possible on milling machines fitted with compensated nuts or recirculating ball screws. Rigidity within the vertical slide and its mounting is of paramount importance. Metal sections should be as stout as is practicable with large areas in firm contact and the stress path between the workpiece and the saddle as short as possible.

End mills and similar cutters are normally only available in the right hand form, whilst conventional milling cutters can be reversed for left hand rotation in particular circumstances. This latter technique is not possible with lathes having 'screw-on' chuck back plates unless the cutter arbor is pulled back into the headstock spindle taper.

General description

The cross vice selected forms the basis of the vertical slide and, whilst of modest cost, appears to be made from high grade iron castings with rolled Acme form feed screws having, in the writer's example, an accuracy of within 0.002 in. per inch. The design is such that clockwise rotation of the screws provides forward motion of the slides. An alternative make and, indeed, the larger unit previously converted by the writer are 'left handed'.

In practice, the integral vice and top slide member is not used (the reader will doubtless find a use for this item), a work holding plate and vice being fitted to the remaining slide and provision made for the bolting of the unit to the lathe saddle with partial rotation in two planes possible if desired. Modification of the feed screw details give positive control of the slide in increments of 0.001 in. – the original dial being graduated in 0.005 in. divisions. Depending on the size of the lathe on



2: The bottom half of the unit, shown here dismantled.

which the slide is mounted vertical movement will vary from about 2in. to a maximum of 3 inches. As the feed screw supplied is of 8 TPI all constructional dimensions are given in inches, but those can be converted should the reader wish to replace both the screw and the nut with those of 2.0 pitch to achieve a metric specification. Critical dimensions and alignments are highlighted but, in general, the final accuracy must depend on the quality desired and the degree of skill employed.

Modification of the castings

Following the complete dismantling of the unit, remove the plastic Acme nut and modify the base to the dimensions shown (item 5). Owners of smaller lathes may find it advantageous to cut off the mounting flange with a hacksaw prior to facing the base using the four jaw chuck (or pulled back to the faceplate via the centre hole). The base should then be reversed and the absolute minimum amount of metal removed from the slide contact face to ensure a flat surface. Similarly the Acme nut bore should be skimmed true and parallel - again to the dimensions shown. The facing of the non gib edge should be left until the slides have been refitted to ensure accuracy as a 'setting' face. Drill and tap the clamp screw hole ($\frac{1}{8}$ in. UNC) and spot face the two existing holes.

Modification of the actual slide involves the removal of the horns and the base on Acme nut - again by hacksaw if desirable - and facing back to the overall width shown (item 7). The bottom end of the slide can then be shortened if necessary - the dimensions given being suitable for a lathe of $3\frac{1}{2}$ in. centre height. Prior to refitting the slides a new gib strip (item 16), is suggested, preferably made from gauge plate. Replace the gib adjusting screws with $\frac{1}{8}$ in. UNC socket head grub screws and nuts and modify a socket head cap screw with provision for a tommy bar, see the assembly drawing.

Refitting the slides

Lightly blue the re-machined face of the base, using the minimum amount of oil with the Engineer's blue and slide firmly on the full length of the ways once only. Using the flat face of a smooth 8in. half round file carefully remove the blued areas, keeping the file clean with a piece of flattened $\frac{1}{8}$ in. copper pipe. Repeat the operation until an overall 'patchy' marking is obtained. Apply blue to the non gib vee surface of the base (which in itself may need some attention as work progresses) and following the mating of this surface with that of the slide, remove the blued areas until a similar 'patchy' marking is obtained. Finally reverse the base slide and use it to correct the gib strip side of the actual slide.

When a satisfactory marking has been obtained the slide should be checked for parallelism, using a micrometer and two pieces of $\frac{1}{8}$ in. round silver steel and the slides corrected, if found necessary, to give an accuracy of within 0.001 inch.

To conclude the operation repeat the whole process using a flat but bevelled scraper and the minimum amount of blue to achieve a good general marking. The slide can then be temporarily assembled and should move firmly and smoothly the length of its ways.



3: The modified base with the slide face lightly skimmed.



4: The slide faced for the 5 in. square plate.

Dismantle and set the base up in the four jaw chuck using two pieces of square tool steel to spread the chuck jaw bearing on the long sides and a piece of $\frac{1}{8}$ in. dia. silver steel clamped in the vee to set the base square using a dial gauge. Check for squareness in the other place with a square set against the chuck face. Lightly skim the non gib strip edge to clean up, thereby providing a datum face for later use.

The mounting arrangement

A decision can now be taken on the means of fixing the slide base to the cross slide - the top slide having been removed, bearing the following parameters in mind:

1) The centre line of the long tailed Acme nut (yet to be made) should ideally be at lathe centre height but a variation of $\frac{1}{8}$ in. is acceptable.

2) As much as possible of the slide base should be over the cross slide area - the 2in. radial swing over the saddle typical of the average $3\frac{1}{2}$ in. centre lathe being adequate for this purpose.



5: Squaring up the mounting block with a fly cutter held in the four jaw chuck.

3) Ensure that when the vertical slide is in its lower position there is sufficient clearance to turn the unit through say 10 deg. to allow key seats to be end milled in taper ended shafts.

The suggested methods of mounting cover two options – that of using the Tee slotted cross slide (if the lathe has this facility) or using the top slide mounting which, whilst restricting the position of the unit provides a ready made means of partial rotation. (See Items 1-4).

The photograph depicts the unit fitted to the tool post location on the writer's 6in. Churchill Cub lathe, which has a radial swing over this surface of less than that of a typical 3in. centre height lathe.

Should there be any doubt as to the squareness of the vertical face of the mounting system use, this can be lightly skimmed using a fly cutter mounted in the chuck or on the face plate, packing up the mounting block or angle plate with parallels to give cutter clearance at the lower edge. This will not, however, overcome any error in parallelism of the top face of the cross slide with the lathe centre line should the vertical slide be rotated from its normal position.

The long tailed Acme nut

The accuracy of the feed screw supplied with the unit should be adequate for most purposes. However, should the reader have facilities available for accurate measurement, the better of the two screws can be used accompanied, possibly, by a calibration chart. The making of a new (metric) screw is not covered by this article other than to state that the thread proportions are similar to those given for the 8 TPI nut.

Whilst phosphor bronze or manganese bronze are preferable, there is no reason why drawn brass bar should not be adequate for the nut, bearing in mind the large diameter of the tail.

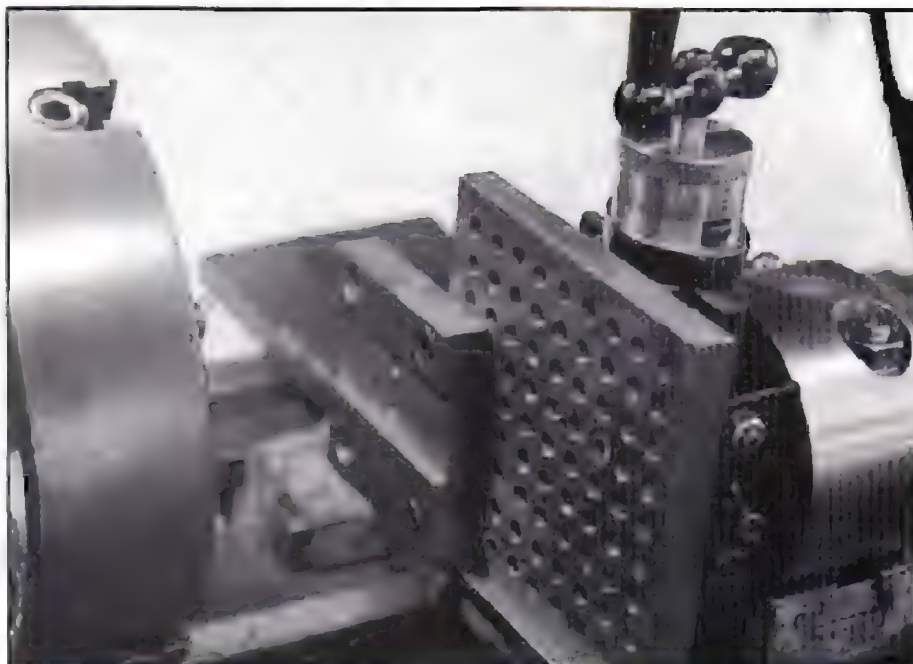
Turn the nut shank to the dimensions shown in **item 6**, adjusting the length to suit the mounting arrangement selected. With the shank a good fit in the bore a 0.002in. diameter step will then give the interference fit necessary in the slide base.

With the screwed end of the Acme feed screw in the three jaw chuck turn the first 1/4in. to barely clean up the minor diameter (this end will be cut off a later stage) to use

8: A method of indexing and cutting the graduations on the sleeve. This was finish turned and bored earlier in the operation.



6: Screwcutting the nut for the Acme thread. Note the use of protective packings under the chuck jaws to avoid any damage or marking of the workpiece.



7: Using a fly cutter to "mill" the relief in the vee jaw block. The polycarbonate guard has been removed in the interests of clarity.

as a reference for the nut bore. (Item 8).

Set up the prepared nut blank in the four jaw chuck keeping the shank parallel with the chuck face. A minimal flat initially machined on the root of the head will prove centrality when the cross hole is centre drilled. Drill and bore 0.020in. larger in diameter than that of the turned feed screw spigot.

An Acme thread is basically of square thread proportions, but with the flanks at an inclined angle of 29 deg. and a theoretical working clearance of 0.020in. on diameter at the root of the screw and at the major diameter of the nut. The writer finds, however, that when the cutting tool tip width is measured with a micrometer, the amount of tip remaining within the anvils gives sufficient clearance.

The tool dimensions are shown on the drawings. In the absence of an Acme thread gauge, an accurate paper chart and a steel rule will suffice, taking care to keep the tool shank at right angles to the 29 deg. centre line. Set the tool marginally above centre height with the shank parallel to the



9: Centre punching the hole pattern on the 6 in. square plate using a home made optical centre punch.

lathe centre line and proceed to cut the thread in the normal manner, checking acceptance of the screw after a depth of 0.060in. has been reached. Aim for a tight fit which, due to the form of the rolled screw, will ease off fairly quickly.

Feed screw bearing housing and graduated dial

With the squared end of the feed screw running true skim the mouth of the tapped hole to 60 deg. to form an accurate centre. Hold the screw on the reduced opposite end and turn the shank to the dimensions shown having checked and corrected any slight 'bow' in the screw. Part off the spigot end.

Prior to machining the bearing housing the preliminary drilling should be used to check the position of the thread in the new Acme nut relative to the two tapped holes in the slide. Using the discarded plastic bearing plate spot the three holes on the face of the housing blank and drill $\frac{1}{16}$ in. diameter, opening up the centre hole to 10mm. Drive the long tailed nut into the bore of the slide base, ensuring that the faced boss is precisely square with the reference face. Drill $\frac{1}{16}$ in. diameter and dowel with an $\frac{1}{16}$ in. nominal diameter roll pin. Assemble the slide and the feed screw. The drilled housing blank should then line up with the 10mm diameter of the feed screw and the two tapped holes. Any error should be noted; which may then be corrected by setting up the housing in the lathe and opening up the 10mm hole to move its position in the desired direction. This operation may need repeating, using a

coned bush to centralise the now larger hole on the feed screw shaft. The bearing housing can now be machined to the dimension (item 19).

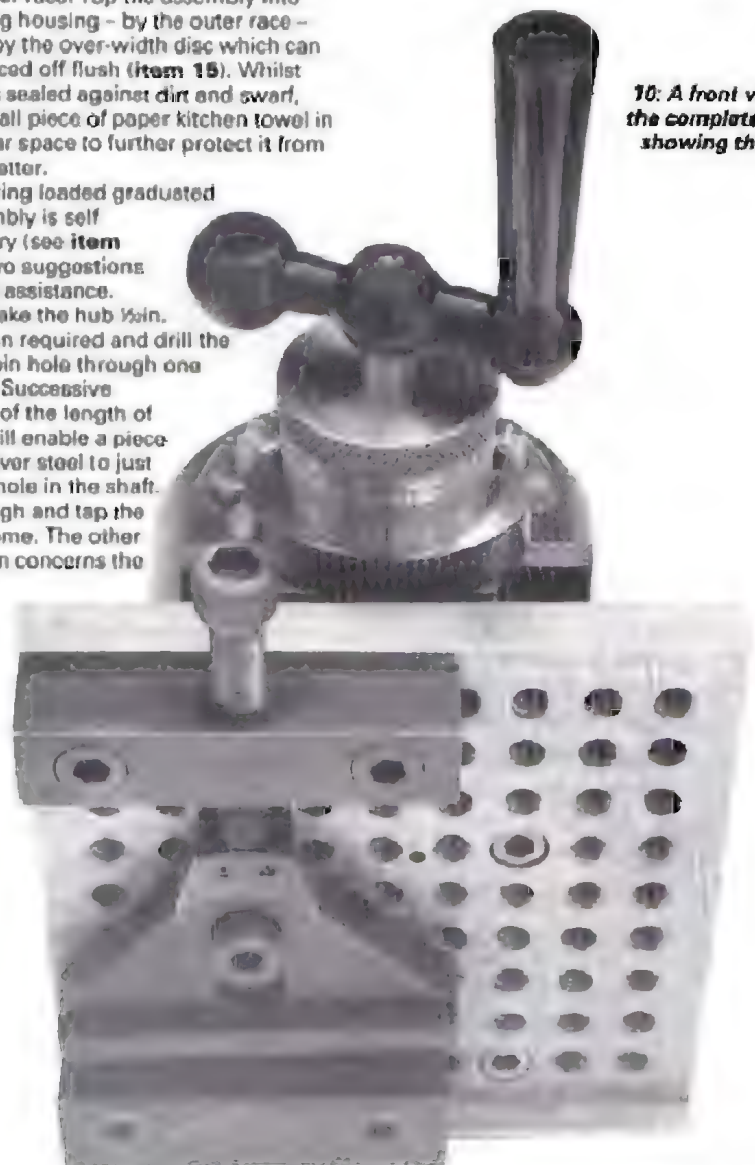
With one of the discarded circlips fitted to the annular groove in the feed screw, tap the ball race up to it using a piece of tube on the inner race. Tap the assembly into the bearing housing – by the outer race – followed by the over-width disc which can now be faced off flush (item 15). Whilst the race is sealed against dirt and swarf, pack a small piece of paper kitchen towel in the annular space to further protect it from foreign matter.

The spring loaded graduated dial assembly is self explanatory (see item 12) but two suggestions may be of assistance. Initially make the hub $\frac{1}{16}$ in. longer than required and drill the $\frac{1}{16}$ in. roll pin hole through one side only. Successive reduction of the length of the hub will enable a piece of $\frac{1}{16}$ in. silver steel to just enter the hole in the shaft. Drill through and tap the roll pin home. The other suggestion concerns the

indexing of the graduated sleeve – which has been the subject of earlier articles in this Magazine – the method using being as follows:-

Bore a piece of $\frac{1}{16}$ in. plywood to provide a tight fit on the o.d. of the four jaw chuck – the writer's being too large – hence the use the three jaw (normally only used for second operations and holding hexagonal bar). Following the fitting of the disc to the chuck turn the o.d. such that a $3\frac{1}{16}$ in. length of steel measuring tape just meets at the ends – a piece of older damaged tape can be used. Secure both ends by small round head wood screws and washers with two additional screws at 120 degrees. A pointer mounted on a magnetic base, together with the use of a magnifying glass, makes indexing (at one quarter inch intervals) a straightforward and relatively accurate process. Should the reader have access to an older or more robust lathe this method, with the addition of a guide held in the tool post, can be used for the subsequent numbering of the divisions.

Alternatively, those having lathes of $3\frac{1}{16}$ in. centre height or less may prefer to use a smaller wooden disc with 5mm 'steps', or to mount and turn the disc on the gear train end of the mandrel, using the lathe top slide on a temporary rig. The two theoretical disc diameters are 9.947in. and 7.832in. respectively, both less one



10: A front view of the complete slide, showing the vice.

QUICK TIP

When using the oil stone for sharpening chisels etc. mix the oil with paraffin (kerosene) in the ratio of 2:1. This will keep the stone clean and stops it becoming glazed. One can keep the mixture in a labelled glass bottle ready for use but do remember to shake the mixture very well before use. This is not my original idea but was taught to me by my late grandfather, who was a qualified engineer, and who taught me this a very long time ago.

Anton Vella

thickness of the steel tape being used.

No details are given regarding an alternative slide handwheel - that supplied with the unit being just adequate - or the reader may prefer to make his/her own to match the other controls on the lathe.

The work mounting plate

Tee slotted plates are both expensive and thicker than desirable - increasing the overhang and, therefore, the rigidity of the unit. The eighty one hole plate suggested (item 10) (this principle being used on proprietary jiggling systems, but with the addition of precision spaced counterbores) provides an inexpensive and easily made option. The overall dimensions can be modified to suit the size of the lathe, but the 5in. square chosen should be generally suitable. Bright mild steel plate was used for the writer's unit, gauge plate being considered too expensive.

The machining of the edges square and parallel may present a minor problem but, with a little ingenuity, can be milled by mounting the plate on the lathe cross slide, using suitable parallels - possibly in two 'bites' followed by careful use of the file. Pre-drilling of the hole pattern would assist the holding down but the marking out is difficult at this stage in the absence of a large angle plate.

Following the accurate drilling of the hole pattern (a home made optical centre punch was used prior to centre drilling the hole locations) and prior to tapping, drill and tap one hole in one of the vertical slide 'rails' and open up and counterbore the matching hole in the plate. With the assembled slide fitted to the mounting arrangement in a horizontal position, the slide base reference face can be levelled and locked using a dial gauge and the surface plate. The drilled plate is then similarly 'squared up' whilst secured by one socket head cap screw. Tighten, recheck and spot the three remaining holes in the slide 'rails', followed by the drilling of two 1/4in. dia. holes for the subsequent fitting of roll pins on final assembly. The opening up and counterboring of the other three socket head cap screw holes and the tapping of all remaining holes then completes this stage.

A little time spent, using Engineer's blue on the surface plate, together with a 6in smooth hand file will provide an acceptably flat surface on the drilled plate. The rear side should also be checked to avoid distortion of the vertical slide when the unit is assembled. Parallelism also needs to be progressively corrected as work proceeds with any minor error being in the horizontal plane for obvious reasons.

The facing of either or both sides of the plate is not recommended as the release of residual stresses introduced during manufacture tend to cause progressive distortion during such machining.

The work holding facility

Considerable thought was given to the design of a suitable vice - commercially available types generally increasing overhang to an unacceptable degree. The principle eventually adopted is based on that supplied with the Drummond 6in. type 'J' hand shaper of yesteryear, which eliminates the effect of sliding jaw 'lift' and accommodates slightly tapered workpieces. This device will, however,



11 - A rear view of the completed slide, arranged for use on the 6in. Churchill Cub lathe. The pin strip adjusting and locking screws can be seen in this photograph.

benefit from the fitting of a piece of 1in. x 1/4in. bright flat mild steel or gauge plate to the lower edge of the 5in. square plate to provide a datum and additional support. A similar hole pattern can be provided on the other edges of the plate if felt desirable.

The vice is simple in the extreme, the sliding jaw being milled prior to cutting the gauge plate into its separate components and affording the first opportunity to try out the vertical slide conversion. As with the 5in. square plate, accurate marking out and drilling of the socket head cap screw holes is essential to enable the individual units to be moved to the required positions. The pressure pad for the sliding jaw is cut from a previously bored piece of gauge plate and may be used to finally shape the radius on the heel of this jaw. The two roll pin holes should be drilled with the spigot of the actuating screw axially held in position prior to forming the annular groove (item 18).

All the components, with the exception of the actuating screw, can now be hardened by heating to a cherry red and quenching in oil - just within the capability of a cartridge type gas blow torch - used with several fire bricks and which should not cause any harmful distortion.

The slide unit will benefit from subsequent dismantling, final deburring of the components with the unmachined parts

QUICK TIP

Makers in their kitchen utensils department sell shallow aluminium trays 470mm x 365mm x 16mm for about £15. These make excellent trays for the Unimat 3 lathes or other small lathes. I bought a scratched and slightly dented one of the reduced price of £4.99. This I am mounting on a 40mm piece of kitchen top with the bolts holding the lathe going right through the tray. 12mm raising blocks will be used to increase the gap between the bottom of the lathe bed and the tray for easy access.

Anton Vella

of the casting being rubbed down and painted to match the lathe to which it is being fitted - the vice parts being left in the 'blued' condition. The 5in. square plate can also be visually improved by 'spotting' with coarse grinding paste used on a 1/4in. diameter wooden dolly in the bench drill, feathering being difficult due to the hole pattern. Thorough removal of the residual abrasive is, however, essential.

Finally, two tips which may assist the above project:-

1) Prior to inserting socket head screws into holes tapped in cast iron, a spot of oil will prevent the risk of seizure and resultant

disaster.

2) When 'picking up' a previously machined surface, such as a bore for that last 'half thou', use a 'harker' - made from a tomato puree tin with a length of 1.8in. brazing wire nutted into the base and bent to a convenient shape. When placed to the ear with the tip of the rod on the tool shank, the point of contact is easily found.

Some thoughts on safety

With the application of milling cutters to workpieces in the lathe, this becomes a milling machine - one of the most potentially dangerous pieces of equipment in the workshop, capable of causing horrendous injuries, particularly to the hands. The writer, therefore, makes no apologies for stating the obvious in the following guide to safe working which is intended for the user of the home workshop and is not necessarily comprehensive or adequate for an industrial situation where, for instance, a person working alone in a machine shop is, in itself, a breach of the Safety Regulations.

- 1) Ensure that the clothes worn provide suitable protection from flying swarf with a tie, if worn, tucked in; with cuffs and other openings securely fastened. Wear stout shoes, preferably safety shoes - even a 4in. chuck dropped from waist height can break a toe or two.
- 2) Wear industrial type safety glasses at all times, even when guards are used.
- 3) Position a means of stopping the lathe in an emergency (such as a double pole isolator switch) within easy reach.
- 4) If working alone with no-one within call, install an alarm to summon assistance should it be required.

- 5) Use a cutter guard at all times.
- 6) Use conventional milling techniques with both cutters and workpiece securely mounted.
- 7) When the spindle is rotating keep the guard in position and both hands on the machine controls. Particular care should be taken with those lathes having a saddle locking device at the rear of the machine.
- 8) Stop the machine when taking measurements or making adjustments to the workpiece or the cutter, preferably using the isolator or by locking the spindle with the back gear. Beware of lever operated drum switches which can accidentally be switched 'on'.
- 9) Immobilise the machine when left unattended and do not allow unsupervised children in the workshop area - the Factories Acts were originally introduced to protect children.
- 10) Should you sustain even a minor injury, treat it immediately - if in doubt or it seems serious, seek medical aid.

Safety guards

Milling machine guards, a legal necessity in industry, have two principal functions - to protect the operator from physical contact with the cutter and to prevent injury from flying swarf, harmful cutting fluids and, in the event of a 'smash', larger pieces of metal. Vision has to be of secondary importance. Such industrial guards fall into two categories.

- 1) Transparent polycarbonate screens between the operator and the cutter.
- 2) Perforated or slotted steel guards partially encircling the cutter.

It is suggested that a clear polycarbonate screen be used for end milling and similar

operations. The type supplied with bench grinders may be suitable or alternatively a larger piece of polycarbonate material fixed to the front of the coolant tray. For milling using cutters on an arbor, the guard used with 1/2in. bench drills can be considered but which may require some modification. The fixing of either will depend on the design and size of the lathe. These suggestions are intended for the user of the home workshop and may not necessarily be acceptable in an industrial or Training environment.

Suggested suppliers

(Usual disclaimer)
Basic cross slide unit
 Draper Tools Limited, Hurstley Road, Chandlers Ford, Eastleigh, Hants. SO5 5VF. Telephone No. (0703) 266355 - who supplied the original unit - their part No. 25555. Draper Tools also stock telescopic chuck guards
Cast iron undrilled angle plates
 Tracy Tools Limited, 2 Mayers Avenue, Dartmouth, South Devon TQ6 9NC. Telephone No. (0803) 833134. Tracy Tools also stock right hand and left hand Acme taps at competitive prices. N.B. We understand that angle plates are available to personal callers only.
 W.D.S. Standard Parts, Pollard Lane, Leeds LS13 1EH. Telephone No. (0532) 581333 - excellent quality but possibly expensive for the owner of a home workshop.
 For those prepared to machine their own angle plates, suitable castings are available from The College Engineering Supply, 2 Sandy Lane, Codsall, Wolverhampton, WV8 1EJ.



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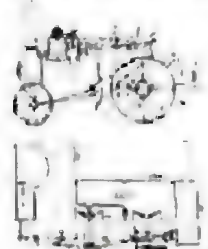
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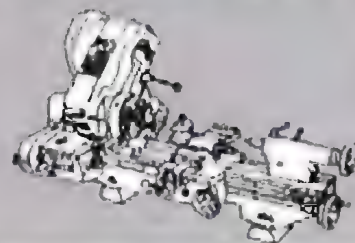
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DELIVERIES ARRANGED HOME AND ABROAD



Bearing in mind that the drilling machine is a much more dangerous machine than most people give it credit for, the addition of a foot switch, as proposed here by Mr D.O. Coe, should be given serious thought, if only from the point of view of operator safety.

Of the three machines most frequently found in the home workshop, the lathe, milling machine and drilling machine, the drilling machine is unique in that it requires two hands at almost all stages to operate it. The one exception to this is when a vice is used and is firmly clamped to the drill table, but this is rarely practical, although every effort should be made to accomplish this. It should be considered essential to achieve secure workholding when drilling large holes, the added complication of attempting this should not deter the operator from ensuring that it is achieved. *(The small tables on many machines do make this very difficult, I often consider that this in itself contributes considerably to making the hazard probable. Could not, for the sake of a few pounds cost, the table be increased in size appreciably? Should this not be considered a design requirement by the Health and Safety Executive for industrial equipment, or perhaps it is. Do any readers have any thought on the subject? Ed.)*

The often overlooked result of having both hands occupied, is that there is no

drilling machine is one which should be treated with more respect than is frequently the case.

Now I am not writing this article to explain safe working practices when using a drilling machine, but to suggest one item which may go a long way to appreciably improve the situation. The item in question being a foot operated switch. Before detailing this, it is worth stating that for any reader who, for whatever reason, considers this addition not applicable, that the siting of the main on/off switch becomes of paramount importance. The switch for a drilling machine should always be within

An overall view of the machine, with the foot switch securely affixed to the slotted angle stand.



A FOOT SWITCH FOR A DRILLING MACHINE

free hand to switch the machine off in the case of an emergency. Overlooked that is, until a dangerous situation arises and then it becomes so very obvious.

The danger

Most readers will have experienced the situation, where the drill becomes captive in the workpiece and the drill starts slipping in the chuck. It soon becomes a panic to free the drill from the work, but if this is not successful, then to switch the machine off. This requires the hand operating the feed lever to be removed from the machine to switch it off which, because this will return the drill to its topmost position, will tend to lift the vice from the table. In all, this is a very difficult and potentially dangerous situation.

I have read on more than one occasion that the drilling machine is responsible for more industrial accidents than any other machine. Whether this is because there are more of them, or perhaps likely to be used by a wider range of operators, I do not know. It is obvious however that the

very easy reach of the hand operating the feed lever. Illustrations seen in magazines frequently show this not to be the case.

Some improvement

Some considerable improvement can be made by the provision of a foot-switch to back up the main control switch. This requires to have a push on, push off mechanism, usually known as a maintained push button switch. That suggested in this article is available from Maplin Electronics, it is a genuine foot operated switch having the necessary robustness for this application, but being of an open construction requires to be mounted in a suitable enclosure.

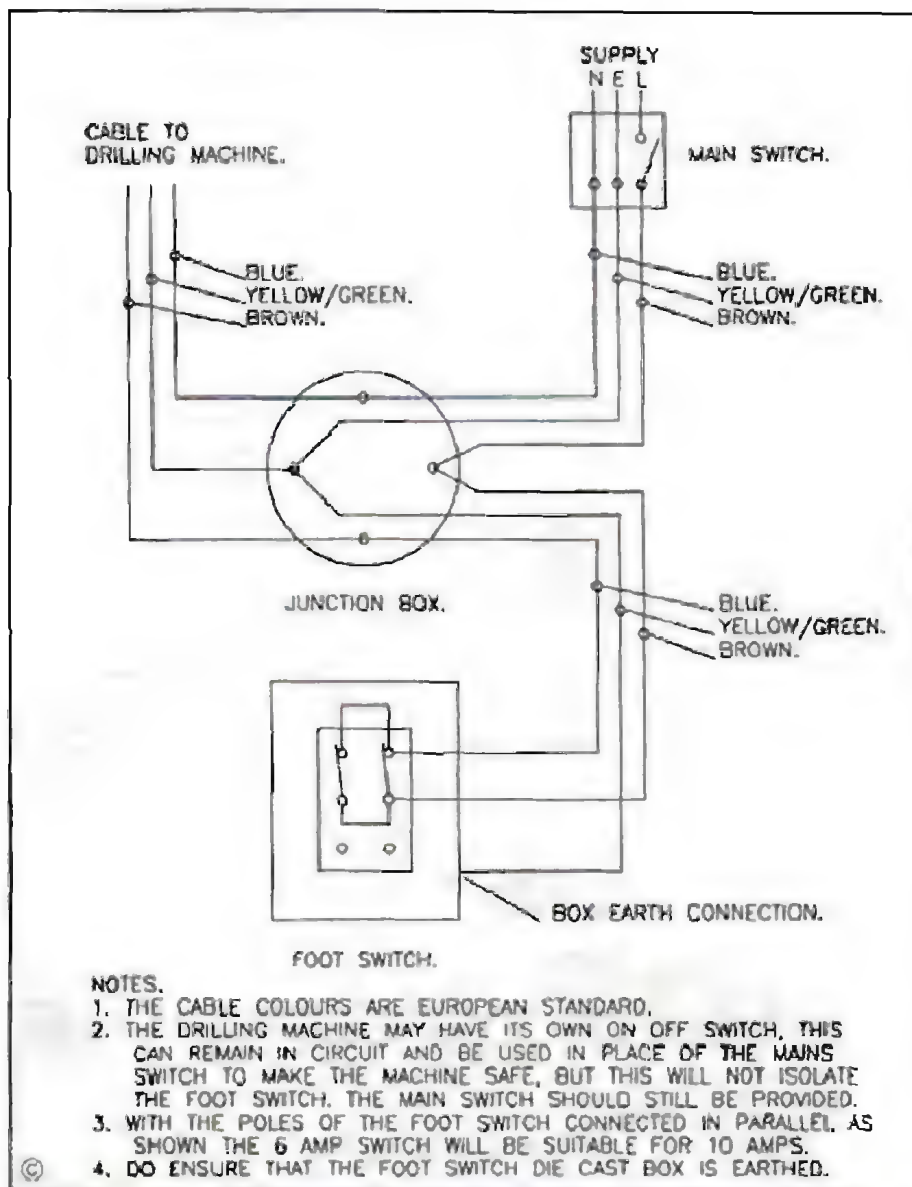
The switch is rated at 6 Amp 240v (see note 3 on drawing) which should be satisfactory for most small drilling machines. If you have a larger machine, check your motor nameplate for confirmation of the full load current.

The box requires to be sufficiently robust, in view of its location, and a die cast box, also available from Maplin

Electronics, is suggested. It is not intended to go into details with regard to the overall construction as it is quite straight forward. From the photograph it can be seen that I have made the foot pedal from a piece of slotted angle, as is the machine bench to which the foot switch is firmly clamped. This is an essential requirement, as should the switch not be rigidly fixed it may be out of position just when required.

Connecting up

To interconnect the motor, switch and mains cables, some form of junction box should be used, this can be seen in the diagram. Under no circumstances be tempted to join the ends using insulation tape. The junction box (also available from Maplin Electronics) should be sited where it will be free from damage due to impact, as should the cables. To assist with this, clip the cable in position as far as this is practicable, this will prevent it getting caught up with items stored under the bench.



A close-up of the switch note the piece of angle used over the actual button of the switch, making for an easier service life.

In use

In use the machine should be started and stopped using the foot switch. Even so,

there should also be a main switch located near the machine. This should always be left in the off position when the machine is not in use, which will prevent the machine

starting if the foot switch is actuated accidentally. With this in mind, it is worth siting the foot switch such that it is easy to operate intentionally but is sufficiently obscure to help prevent it being operated in error. The main switch should also be in the off position whilst the machine is being set up.

Do also bear in mind that, should the foot switch be operated in error whilst the main switch is off, the machine will start when the main switch is switched on. This is particularly so, as with the push on, push off, switch there is no visual means of telling whether the switch is on or off. In an ideal situation the drilling machine would be controlled with a no volt release, direct on line starter, and a foot switch just being a normal stop push button. Unfortunately, the addition of this ideal solution may cost nearly as much as the drilling machine itself.

The materials suggested from Maplin Electronics can obviously be obtained from many other sources, but do take care that the push on push off switch is of sufficiently robust construction for use as a foot operated switch.

Do give serious thought to adding this provision to your machine, one day you may be very pleased that you have made the effort.

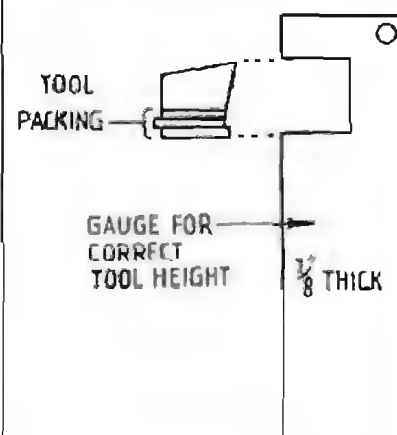
Materials

Supplier Maplin Electronics, PO Box 3, Rayleigh, Essex SS6 2BR. Tel. 0702 554161.
Foot Switch, DPDT switch 6 amp. Type Press Toe DPDT. Order Code FH93B.
Box, Die Cast 116 x 61 x 36. Type Box DCM5004. Order Code LH7 1N.
Junction Box, 15 amp. Type Junction Box Large. Order Code HL65W.

QUICK TIP

To save time when setting the tool height make a gauge which will enable one to assemble the correct amount of pecking required to give correct tool height before clamping tool plus pecking into tool post. Simple, but very effective.

Mr Plummer



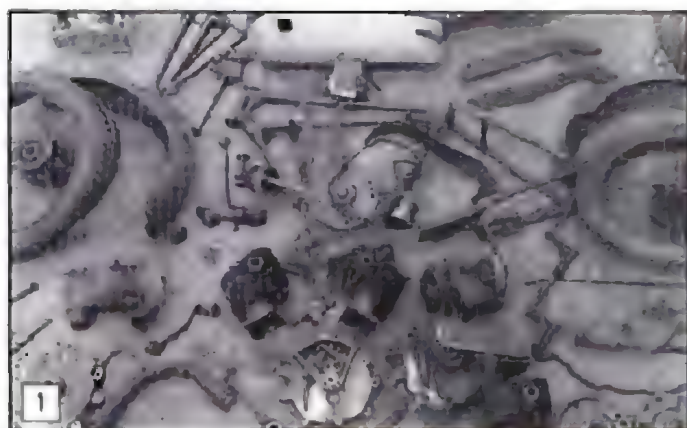


Albert Wallis has an interest common with quite a few readers of this magazine, that is restoring vintage motor cycles. In Albert's case, his interest is in those made between 1919 and 1940 by the Brough Superior Company of Nottingham.

Anyone visiting Albert Wallis for the first time will, I am sure, soon become aware of his considerable passion for the Brough Superior Motor Cycle. They will however, realize that he is a man of many interests, and that motor cycling is but one of those.

Albert has had a very varied working life mostly outside an engineering environment, but this has not stopped him having an interest in engineering. This interest has been a lifelong one having started when he was but a small boy, now being 82 years old. He has had a long involvement with motor cycles, particularly those made by the Brough Superior company.

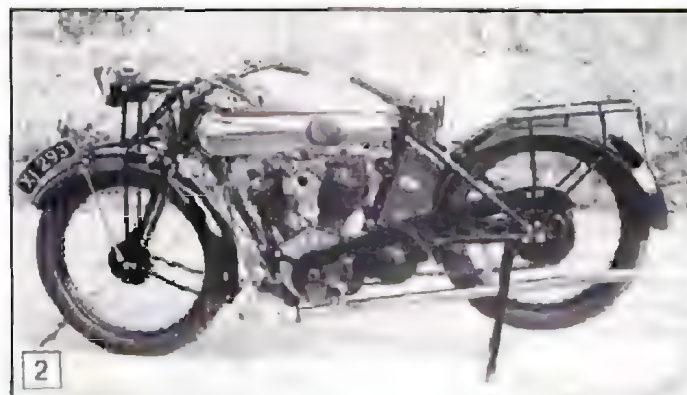
WORKSHOP VISIT - ALBERT WALLIS



1 & 2: A 1922 Mark 1 before and after restoration.



3 & 4: A 1924 SS80 before and after restoration.



The Club

His interest in the Brough Superior motor bike, lead him, together with 12 others in the Coventry area, to commence, in 1958 the Brough Superior club. Membership of the club now numbers some 400 with members in such countries as Australia, New Zealand, Japan, USA, South Africa, most western European countries and many others. The club has an annual run, not necessarily in the U.K., and also a separate Annual General Meeting which members from many countries attend.

The Company

The Brough Superior company was located at Nottingham employing at times up to 99 workers, apparently the founder and owner of the company, George Brough, had some reservation of moving to a 3 figure work force. Commencing manufacture of motor cycles in 1919, the company continued until 1940 by which time about 3500 machines had been made. The club keeps a register of bikes known to be surviving and this now lists around 1200. This is I feel, quite a remarkable survival rate, as in any event there are also likely to be others surviving but not listed, highly probable as bikes are scattered world wide.

Albert's involvement with the early days of the club brought him into close contact with George Brough and his wife, to whom Albert and his wife became well known.



5: A replacement roll over stand in the course of construction together with its welding/brazing jig.

In addition to his machines, Albert has a considerable library of relevant publications. This includes bound copies of *The Motor Cycle* magazine from 1916 to 1942, a magazine which according to Albert is no longer published. He also has photocopies of all articles relating to the Brough Superior bike that have been published. These he has obtained through the services of the very extensive library at the Beaulieu motor museum whom he has found to be most helpful.

To back up the published text which he has, Albert brings into action one of his

were produced, and these were few, have been lost. Because of this, any restoration work has to be done with only the bike itself as a guide, and any others of the same model that can be inspected.

The works patterns

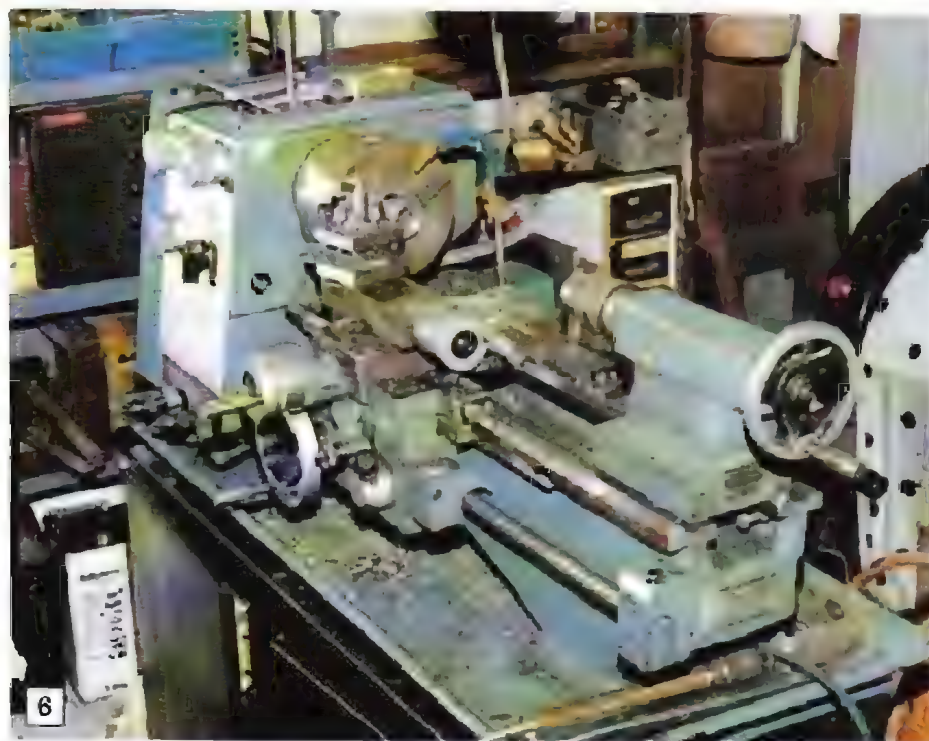
Albert was fortunate to acquire a large number of the actual patterns that were used for the manufacture of most of the castings that were ever required. He has however on occasions had to make his own patterns for those not acquired from the works. From the works patterns, and those made by himself, he obtains castings in cast iron and aluminium which he either machines himself or supplies to other members of the club for machining. As well as castings, plain or machined, Albert makes and supplies many spare parts to other members of the club, mostly made on a one off basis as there are few repeat orders. The roll over stand seen in photograph 5 is typical of these.

There are however some aspects of restoration that he is happy to leave to others to perform, these include stove enamelling of any painted parts, obtaining stencils for any lettering and logos required. One very specialised requirement is the fuel tank, there is fortunately however, one member who is able to undertake the operation of making these, and who has apparently now made a business of this. This is obviously a very skilled and time consuming operation, as a result they are not cheap, costing I understand as much as £400.00, mud guards are made in a similar manner.

One small item that occurs is the requirement for ball handles, quite similar to those that appear on machine tools. These in the vintage transport field are called tiller nuts. As an indication of the degree to which the aim is to reproduce the original as faithfully as is possible, these tiller nuts are chromium plated as one would expect, but if for a bike that is pre 1928 they have to be nickel plated.

Locating a bike

Bikes for restoration are becoming few and far between with probably only two or three bikes turning up in any year. Bikes have, in the past, turned up in many places frequently in very poor condition. In the case of one of the bikes illustrated in this



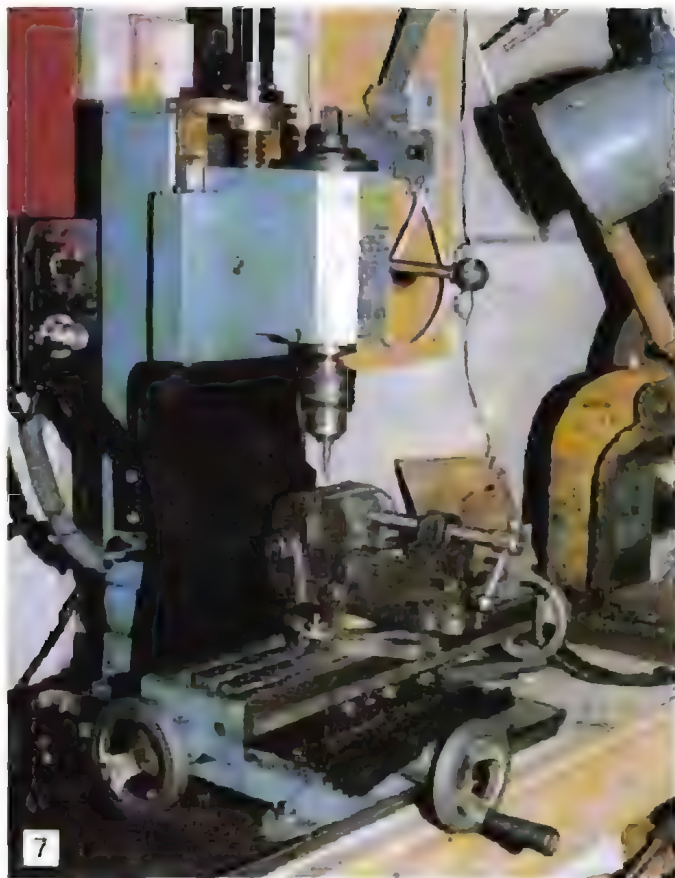
6: The Excel lathe.

His Collection

A measure of his interest in the Brough Superior motor cycle can be gained by the fact that he, together with son and daughter in law, now own 8 such machines, all of which have been lovingly restored. The three of them can frequently be seen at rallies riding their machines. His son and daughter in law have a more general interest and as a result have a further seven bikes of other makes.

other hobbies, photography. He has for many years taken his own black and white pictures also processing and enlarging them as he requires. He likes to take pictures of the motor cycles as he acquires them, and then after completing restoration. Examples of this can be seen with this article, more about that later (photos 1 to 4).

There were no workshop manuals produced for any of the models and apparently any factory drawings which



7: The small Excell vertical milling machine.

8: Universal band saw with gravity fed suds system.

9: The short length material holders for use on the band saw.

10: A third hand. Simple but effective.

article Albert was told by a chance acquaintance of a bike owned by another. On contacting the owner he was told that it could be found behind the shed on the allotment, but that it was largely covered by accumulated rubbish. When arriving at the location it was found necessary to dig it out with fork and spade.

The Workshop

For his workshop, Albert, like many, uses his garage, as a result the car is relegated to the car port. The garage with all its workshop items just leaves room for the storage of one of his bikes this an unusual machine having two rear wheels.

This is not like the rather weird tricycles, one sometimes sees being ridden by younger bikers. It does have two wheels quite close together being only about 50mm between the two tyres, as a result it does at first sight look quite normal, this is featured on the front cover.

His workshop is equipped along fairly conventional lines, his lathe (photo 6) being perhaps a little larger than most having a centre height of around 5 inches. The vertical milling machine (photo 7) is on the other hand smaller than many and of a design not frequently seen, having a vertical column with dovetail slides rather than the common round pillar. This overcomes the failing of the round column

type, being loss of registration when the head is raised and lowered. Both the lathe and the mill are supplied by Excel Machine Tools of Coventry (Tel: 0203 365255).

Albert speaks highly regarding the benefit of having purchased a universal band saw (photo 8) of the type now available from many suppliers, his being from Warco. Close examination of this photo will reveal that Albert has equipped the machine with a simple gravity fed suds tank, surely an idea that could be beneficially adopted on many machines. Also for use on the band saw he has made some bushes (photo 9), these he uses to hold quite short lengths of bar which otherwise would not be able to be held in

37

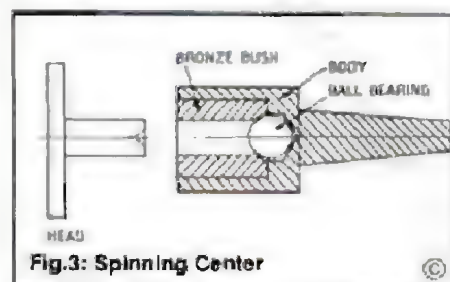
Alan Jeeves provides this interesting article on metal spinning, a subject that has been requested by more than a few readers of M.E.W.

Take a circular blank of metal sheet which is to be made into a dish. A sandbag and bossing mallet can be used to form the dish by beating the blank with the mallet and rotating the workpiece until the required result is achieved. You can use a doming block and punch or doming hammer to obtain the same result. In sheet metalwork this process is known as hollowing. If the same blank of metal were to be placed against a revolving former, secured in the centre, and pressure then applied to it to force it towards the former, the dish could be produced much more quickly than by hollowing. This process is known as metal spinning. In days gone by a special spinning lathe would have been used by companies who specialised in this kind of work, and today companies exist who can produce shaped work which has been spun. One example of modern spinning is the use of dished ends on pressure vessels where a blank of

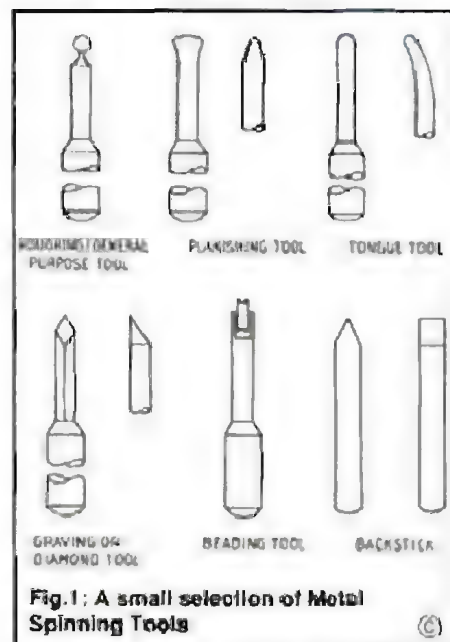


The tool rest

Sometimes called a 'T' rest, it is used to lever against and should be very robust. If the whole compound slide of the lathe is removed the new attachment can be fitted in its place. The holes can be drilled and reamed and the pegs made a good fit in them. The height of the tool rest should allow for the tools to be used just below the centre height of the lathe. The dimensions of the rest will, of course, vary depending on the lathe available. The pegs too should be robust, 13mm dia. shanked down to 10mm dia. being a good size. The whole unit can be fabricated out of mild steel and welded or screwed together, the actual rest section being long enough to give a good selection of fulcrum holes, say 150mm.

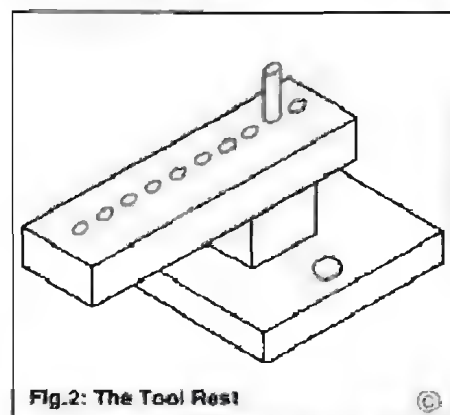


METAL SPINNING



say stainless steel 5 metres in diameter and 16mm thick can be formed into a 'dish' without much trouble at all. This, of course, would take place on a huge and powerful machine tool designed specifically for the job, but for producing much smaller work out of much thinner material the work can be carried out on a centre lathe.

The type of work which may be attempted at home will depend upon the size of the lathe available. Nevertheless, a 50mm steam dome for a locomotive, for example, can be produced out of 0.75mm thick brass on a 3 1/4 in. centre lathe. Clearly to achieve this the machine will have to be modified in order to cope with the new role it will take on.



As the tools are hand held there is no need for a tool post, so this can be removed from the lathe. It is probably better to remove the whole compound slide and replace it with a quite separate assembly, made up to suit the lathe which is being utilised. As can be seen from the drawing, this rest is similar to the tool rest found on a woodworking lathe, except that the top of the rest is drilled with a series of holes. Round pegs are located in these holes and are used as fulcrums from which to lever the workpiece towards the former, using the various tools. The workpiece blank is trapped between the former and a revolving tailstock centre which has been modified to suit the job in hand and here again it is probably better to make a completely new revolving centre with a selection of removable heads, the number of which can be added to as required. This then is the basis of metal spinning. The equipment required is relatively simple to make and the range of products which can be made is vast, limited only by the size of lathe and the power available.

The spinning centre

The spinning centre can be made up out of mild steel and the heads can easily be made to suit individual requirements. A Morse taper is turned on one end to suit the tailstock of the lathe and a hole is bored in the other end to take a brass bush which is pressed in. Before the bush is located, a ball bearing is dropped into the hole, the diameter of which is slightly larger than the bore of the bush, making the ball captive. The heads can now be made out of mild steel with shanks to suit the bush. The required head is greased and inserted into the bush so that it locates on the ball thus providing a very effective spinning centre. A standard revolving centre can also be used by making separate heads to suit, but much will depend on the discretion of the individual as to which centre he uses.

Formers

The former which the work will be spun round is sometimes called the chuck. It takes the form of the inside dimensions of the finished job and will have to be made especially for the job. Formers can be made out of wood, steel, cast iron, brass etc. but if repetition work is anticipated, steel will be best. Hard woods with a close grain are best for the wooden formers, maple being especially good. Most of the home workshop spinners I know find the most convenient way of obtaining material for formers is via the local scrap yard. Small formers can be held in the 3-jaw chuck when being used but it is far better to be able to make them so that they screw directly onto the spindle nose, incorporating a method of easy removal also.



Left hand page: A selection of objects that can be produced, wholly or in part, by metal spinning techniques. The scales were spun only in part.

Above: The spinning centre with a selection of heads made by the author for various jobs he has undertaken.



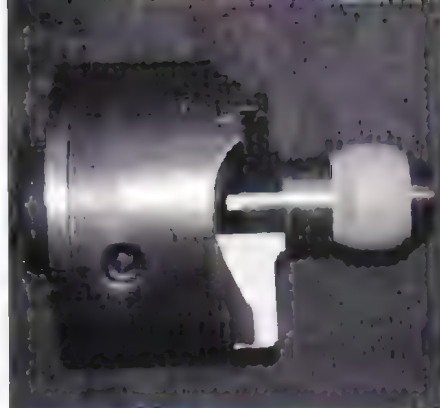
A selection of formers used by the author.



A selection of spinning tools. left to right: general purpose tool, tongue, planisher, point and knob.

The tools

The tools used in the spinning of metal are hand held by the operator and manipulated to force the workpiece against the former. They need to be made so that they are strong enough to withstand the leverage, and large enough to enable a good grip without slipping out of the hand. I think it very unlikely that spinning tools will be obtainable commercially these days. Any tools required will have to be made by the craftsman to suit his own requirements. The tool tip must be very hard as it rubs against the workpiece at high speed and under pressure from the leverage. It must also be polished to a high standard if a good finish is to be achieved on the job. A mirror finish will also reduce friction at the tool tip and tools should be oiled to prevent rust when put aside. Round silver steel, hardened and tempered, may be used to make tools and also old files may be found useful if annealed, shaped, and then re-hardened. When a suitable tool has been made it must be securely fixed to a sturdy handle of around 500mm in length, usually made of wood.



A collapsable former, seen here intact and ready for use.



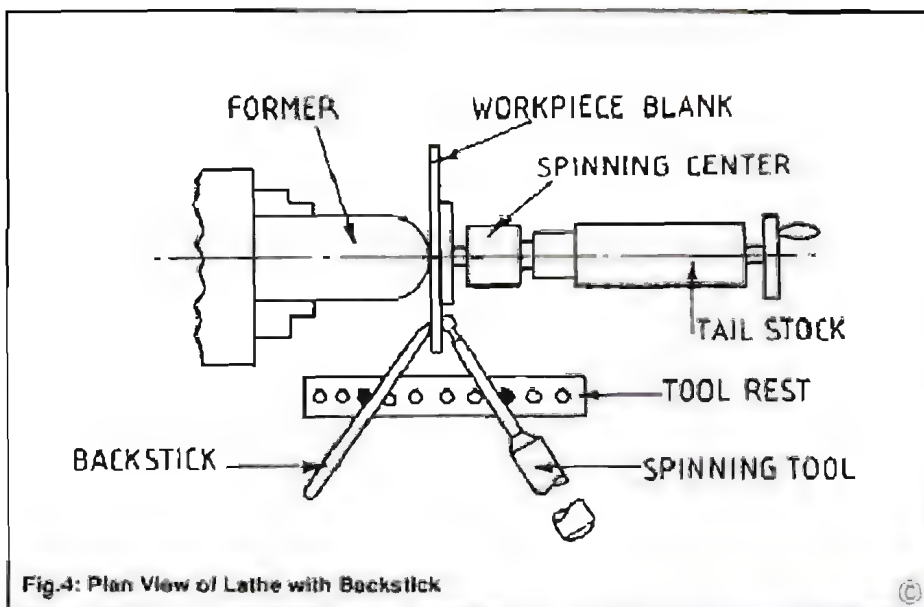
The same former, broken down into its component parts.

The tools are divided into three groups. **Forming tools** which force the work against the former, **cutting tools** which remove surplus material and can form grooves, and **wheel tools** which are used to form beads for strength, safety, or decoration. Forming tools are always blunt with all edges nicely radiused so as not to dig into the workpiece. To begin with only a few forming tools may be necessary, adding others later as more complicated work is undertaken. A tongue tool may be considered essential as this tool will be used to start off the workpiece when beginning a job, known as 'breaking down'. It will also be found useful for smoothing out creases when the forming has been done. A general purpose tool will also be needed as this tool will rough out to shape very well and is easy to use.

It is simply a ball ended tool which is very hard and highly polished. A third tool to acquire is a planishing tool and its careful use will produce a good quality finish, smoothing out marks left by roughing out tools. These three tools



The author at work on his c.1912 Henry Milnes lathe which is used for all his spinning activities.



grease or tallow. The fulcrum peg is simply moved up a hole as the work takes shape.

As the pressure is applied to the work the metal will be certain to work harden. Stainless steel is notorious for this. If the situation is that no further progress can be made then the blank should be removed and annealed, but on the smaller brass and copper jobs it should be possible to complete in one session. Most of the work done on small lathes will probably be out of soft material as mild steel and stainless steel will be found very difficult to spin. Because of the high loads on the smaller machines the spindle can be significantly slowed by the friction created.

When working towards the outer edge of the blank, the backstick must be used directly behind the tool to prevent the metal from wrinkling. If wrinkles occur they will be very difficult to remove. The backstick can also be used to form a flange on the work in order to put a bead on the lip. The backstick is then transferred to the right hand and the edge of the metal is

should produce work of the simple forms chosen when beginning metal spinning.

When the component is completed it will probably have to have some surplus metal removed. This is done by turning off with a sharp pointed tool called a graver or diamond, rather like removing material when wood turning. To finishing off the edge which has just been turned a beading tool can be used to roll the lip over. Beading tools take the form of a wheel and depending on the size of bead required, the wheels are made accordingly.

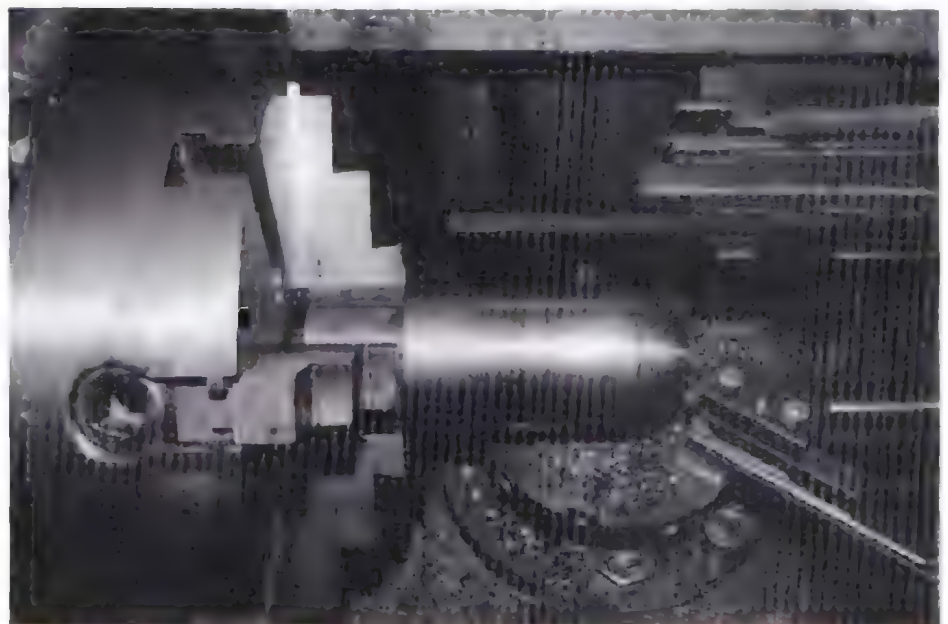
In days gone by wooden tools made out of Hickory were used for breaking down articles made out of pewter or copper. For articles made out of steel, brass or phosphor bronze tools were used, so as the interest in spinning progresses, so will the range of tools the craftsman will want to try.

When the outer edge of the blank is being worked on, it may be supported from behind by a wooden tool somewhat like a long cold chisel known as a back stick. Any hard wood will make a suitable backstick, an old hickory hammer shaft being ideal.

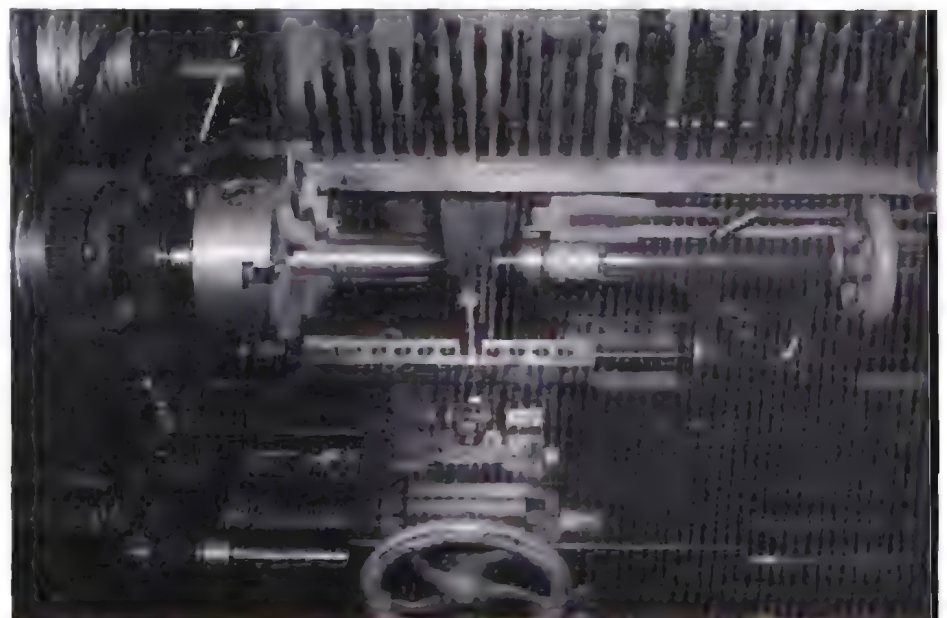
When all the basic equipment has been prepared, the actual spinning of a job can be undertaken. The first requirement is to equip yourself with safety glasses and protective clothing, say a leather apron. The lathe will be running at relatively high speeds and in many cases the component blank is only held in the machine by the friction applied by the tailstock.

It is not unknown for discs of metal to be seen flying round the workshop. The edges of the workpiece will probably be sharp and when rotating will make light work of hands or fingers.

It is best to start with the softer materials until some experience has been gained and aluminium is a very suitable material for practice pieces. The blank is cut out in the form of a circular disc and mounted between former and centre, and trued up as near as possible. The tool rest is positioned to best advantage and a peg located in one of the holes near the tailstock end of the rest leaving the holes to the left of it vacant to re-position the peg as the job goes on. The lathe is now run at high speed, say 900 rpm for the 50mm brass steam dome cover, and the blank literally forced around the former with the chosen tool which is kept lubricated with



As can be seen in this photograph a ball turning attachment comes in very handy when making the formers.



The lathe, seen here set up for metal spinning.

raised at 90 deg. to the axis of the former. By plunging the beading tool into this flange a bead can be neatly formed, thus finishing off the workpiece.

The actual skill of metal spinning will have to be acquired by practice and experience. The first job off the lathe will be far from perfect. The craftsman will acquire techniques of his own as he goes along. Because of the great difference in the size and power of the home workshop lathe, every worker will have a different approach. My experience is with a lathe having a swing of 270mm driven by a 1½ horse power motor, through twenty speeds. The techniques are very different from a 180mm swing with a ½ h.p. motor through four speeds. The man with a 3-horse power machine will have more scope than myself. In this article I have tried to lay out the basics of metal spinning in order to help people who have thought of trying spinning and not been able to find suitable information and encouragement to start them off.

Making the tools

As with most lathe work the metal worker undertakes, the quality of the finished product is directly related to the quality of the tools used. Given that all tools used in metal spinning will in all likelihood be home produced then the theory that it is just as easy to make good tool as a bad one is true. The best material for the home user is going to be silver steel, being easy to work with, easy to heat treat, and having a carbon content of around 1.1%, it is ideal for such tools. If the whole of the tool up to the tang is made out of silver steel it is going to consume large amounts of this material, therefore I make mine by inserting a tip into the end of a mild steel shank. I drill and ream a hole in the shank 25mm deep and turn a spigot on the tip 24mm long. The spigot is 0.05mm larger in diameter than the reamed hole. By carefully heating up the shank so as to cause it to expand, the cold tip can be slid into the hole and the shank then shrinks on to it. When completely cooled the tool is still soft enough to be machined without resorting to annealing. The required tool form may then be produced and when the maker is satisfied, he can harden and temper it.

If heated in a muffle furnace the tool should be heated to a temperature of 780 deg. C but if it is heated by a blowlamp flame it should be taken up to cherry red before quenching in clean cold water. It can then be tempered by heating to 240 deg.C and quenching, or if using the colour method it should be quenched when dark straw is visible at the tip. It can also be tempered in the gas oven at gas mark 9 if left long enough to 'soak'. The tool should then be hard enough to spin metal and resist high pressures.

The spinning tool then has to be fixed to a long handle which usually takes the form of a shaft of wood. I am in the habit of having a very comprehensive range of tools at the ready and if I think a certain shape would suit a certain job I will make the tool up to do the job and then add it to my existing range. I also have some shapes of tools made out of bronze and one or two high speed steel examples. At the outset I realised that a lot of wood for handles would be required so I decided upon a method of making tools which were

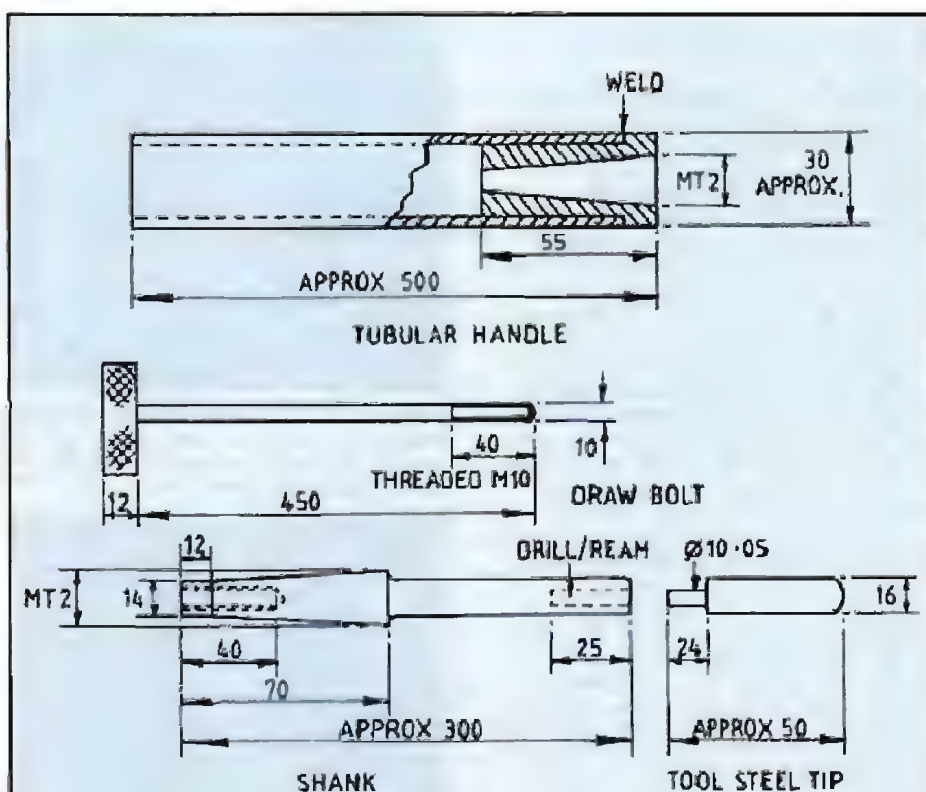
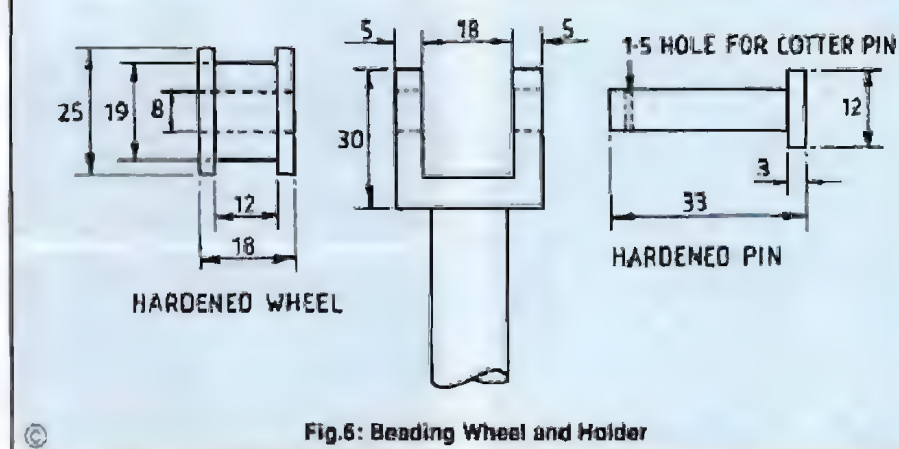


FIG 5 COMPONENT PARTS FOR SPINNING TOOLS



interchangeable in a common holder, yet remained absolutely robust and safe when in use. I made up my handle from steel pipe and into one end I welded a bush which I had already machined with a Morse taper. I then made a draw bar to go through the pipe from the other end with a large cap on which was knurled to offer a good grip when tightening or slackening. Now if I made up standard steel shanks with a Morse taper on one end and a tool steel tip on the other they could be easily fitted and removed from the handle and also are very convenient to store in a rack with a series of holes in just smaller than the Morse taper.

A further advantage of this system is that the tools are much easier to handle when polishing the tips. I polish mine very regularly as this is essential for a good finish and also to reduce friction when in use. I have a pedestal polishing machine for this job but the shanks, having the advantage of a Morse taper, can be polished in the lathe at high speed if preferred. I now have three handles made up so that I can set up for the job in hand

and encounter very few tool changes. Drawings are provided (Fig. 5) for this system of spinning tools for those who think they will do enough work to warrant it. These people will find that high quality tools will last a great number of years and additions to the tool rack are easily afforded. I suspect that the craftsman who makes up a system in the manner I have described, entirely in his home workshop will be rewarded, as I have, with much satisfaction. The number of tools is up to the individual and it may be that he needs only three or four different types to carry out the type of work he wishes to do. The choice of tool steel too can be at his own discretion as some may be more readily available than others. One of my favourite general purpose tools is made up out of EN 31 ball race steel, oil hardened and tempered and produces excellent results.

For beading, or rolling over of the edge of the component to form a lip, a tongue can be used; but usually a wheel is used. When a flange has been formed at right angles to the work the wheel is pushed onto it, at a slight angle at first to roll the

The next four photographs show a little of the sequence of operations in the spinning process. Note the use of the backstick in the first; the partly spun dome in the second; the ragged edge left at the conclusion of the forming operation in the third, and the end result prettied up and gleaming in the last.

A dark, grainy photograph of a large industrial machine, possibly a lathe or mill, with a bright light source on the left. The machine has a complex structure with various components, including a large cylindrical part in the center. The background is dark and indistinct.

A dark, high-contrast photograph of a mechanical assembly, likely a turbine or engine component. The image shows a central shaft or rotor assembly with various structural elements, including what appears to be a compressor section on the left and a turbine section on the right. The lighting is dramatic, highlighting the metallic surfaces against a dark background.

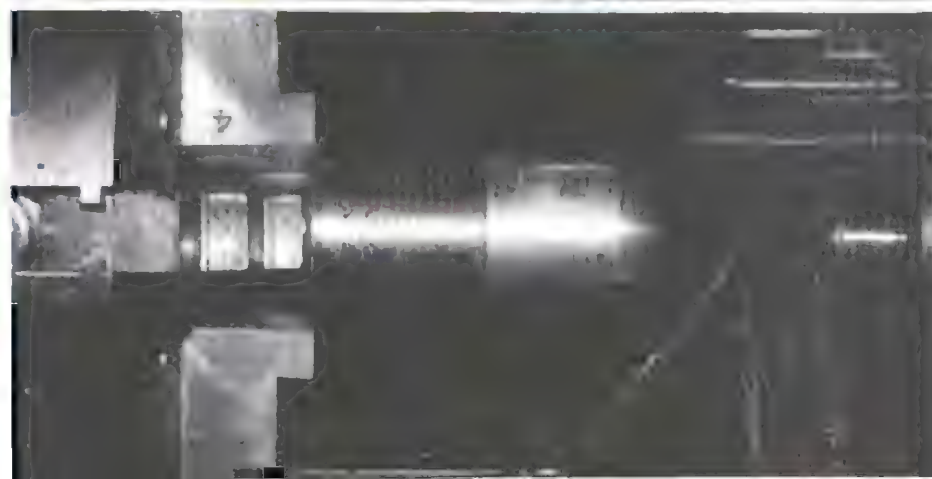


Fig.7: Use of Breaking Down Formar

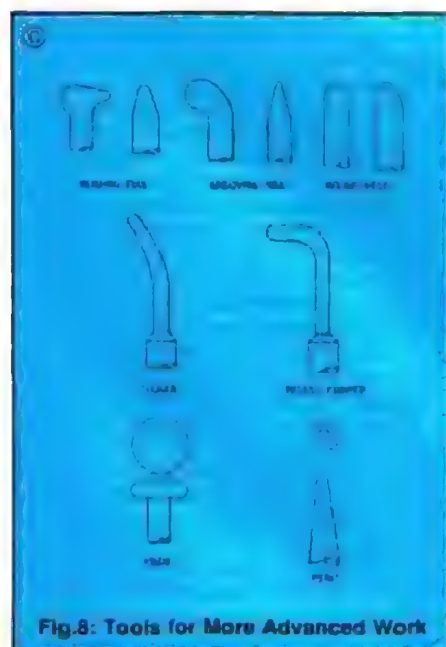


Fig.8: Tools for More Advanced Work

Annealing Chart

Material	Temperature deg. C.	Appearance at temperature
Mild Steel	850	Bright cherry red
Aluminium	340	Chars white dust
Brass	540	Dull red
Copper	540	Dull red



These are the component parts of the spinning tool, the handle, drawbar and finally the business end of the tool, which is fitted with a No. 2 Morse taper for insertion into the handle.

design, it must be remembered that all corners should be heavily rounded so as to encourage the metal of the component to 'flow' as the work progresses.

No work can be contemplated on the metal spinning lathe without a former. Whether the former is made out of hard wood or steel is a matter of preference and availability of material may decide on which. A wood former screwed to a backplate may be easier and quicker to make but for repetitive use the steel version cannot be surpassed. Also if the component is to include any recesses or sharp corners a steel former is essential. It will be clear that quite a lot of work will go into a job before the actual spinning of the component commences.

On some jobs the work may have to be formed over a 'roughing out' former before finishing on the true former. An example of this is a tall vase. Too much spinning would have to take place without being supported so a simple former would be used first to 'break down' the vase before transferring to the true former. The dotted line in Fig. 7 shows a suggested form to use first, thus getting the job started in a much more simple fashion. Again manufacture of formers will be a matter of experience. Generally speaking the outside dimensions of the former will be equal to the inside dimensions of the job. Most work undertaken will be ornamental work and close tolerances should not be encountered. Once a good former has been made any components run from it should be virtually identical. As it is very rare to find any reduction in the thickness of the stock material, by the pressure of the tools as the

is to be of a type which always reduces in diameter towards the tailstock. To spin a 'waisted' vessel or one which is necked down towards the headstock is a different matter. How do you remove the former? Some projects can be made in sections and soldered together when each section has been spun. A sphere can be produced this way, it is, however, possible to spin an object which is bottle-shaped by the use of a special former which is made up of segments which can be secured together and then machined all over. When the spinning has been completed the former is dismantled and each segment is removed from inside the ornament. The usual method of achieving this advantage is by using screws and wedges which are easily accessible from the mouth of the component. Fig. 9 shows such a former being of four segments for ease of drawing but in reality more segments would be required in order to remove it from all but the shallowest of contours. The photographs show a similar former with six segments but careful design is essential to suit the job in hand. You have to be sure it will come out when dismantled. This, I think, is a highly skilled part of the spinning of metal, like a ship in a bottle. A combination of materials can be used for 'collapsible formers' the segments being made out of wood as it is easier to cut. If the example in the photograph was made completely out of steel much hacksawing would be necessary for the average home workshop engineer.

Oddballs and annealing

Another less complicated way of

annealed using a blowlamp and simple hearth. The non-ferrous metals are heated up and then plunged into clean cold water. Steel has to be heated and then left to cool very slowly. Steel objects can become quite tedious to spin if no other job can be undertaken while work is cooling. A table is provided giving the annealing temperatures of the most used materials, along with their appearance at that temperature. Aluminium is included but will usually spin without annealing. Lead will also spin without annealing, as will pewter which lends itself to metal spinning beautifully. Probably the most popular metals for home shop work will be copper and brass. They will take a high polish for ornamental work and are quite easy to get hold of. After annealing the work can be

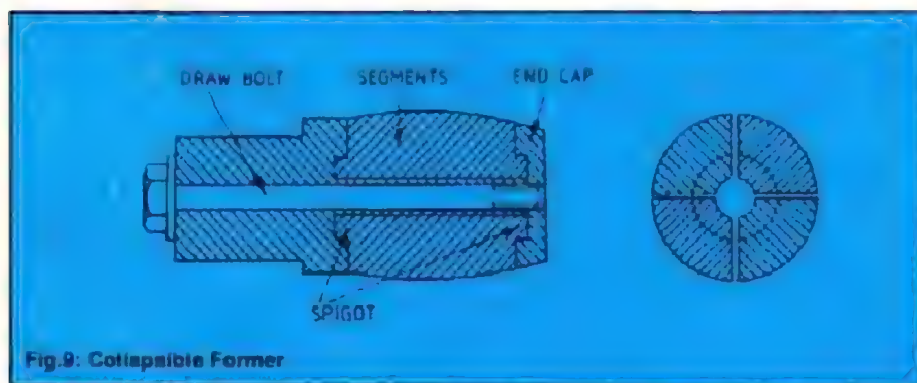


Fig. 9: Collapsible Former

work progresses, if it is spun well. Indeed it is possible for the experienced spinner to increase the thickness of the stock material by carefully working from the outside to the centre. Normally a job is spun by manipulating the tool in both directions i.e. from the centre out and then from the outer edge to the centre. The aim is to spin the metal blank into a shell which is down tight onto the former. A final working over with the planisher smooths out tool marks and this part of the process also makes it easier to release the job when finished.

This is all very well when the job in hand

producing waisted articles is by a process known as spinning in air. Here two formers are used, one to form the main profile and a second to produce the waist. As the name suggests on the second operation part of the job is supported inside by nothing but air. Fig. 10 should demonstrate this quite clearly. Much care is required to spin in this fashion, when changing formers or before 'going down the other side' on a bottle necked former, a good opportunity for annealing the work arises. When coming up against work hardening most jobs should be able to be

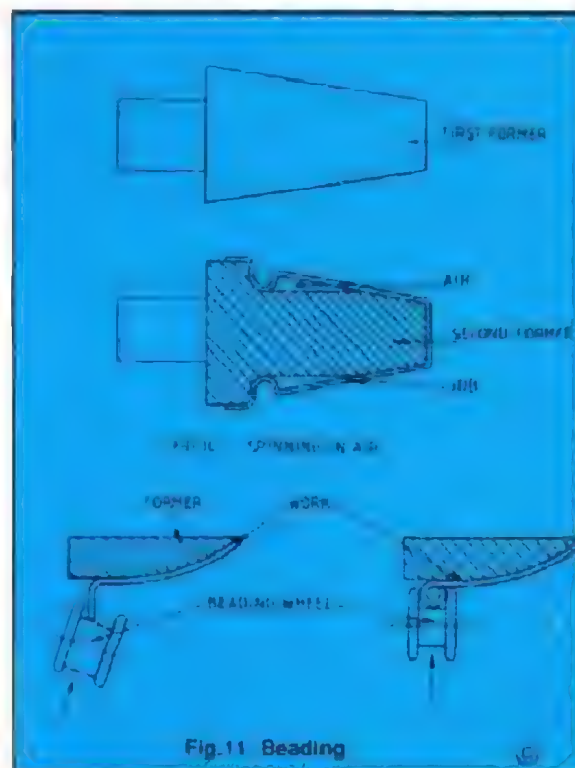


Fig. 11: Beading

returned to the former to be continued.

A point to watch as the progresses is the fact that the grease used for lubrication builds up and can fly off in all directions so it is essential that eye protection is worn at all times and a hat is useful too. As with any other job in the home workshop, as every craftsman knows, the emphasis must be safety first.

We are sorry for the quality of some photographs on this article, but as they are of the actual spinning operation we did not feel that we should ask for them to be re-shot. Ed.



1: Shows two box angle plates partly machined with the wooden pattern in the foreground.

2: In an inverted position two nodular iron crankcase castings, for 16 megawatt medium speed diesel engines, await the next step of manufacture.



Box angle plates have been around for a long time in various forms, sizes and proportions. They are also known by other names but the merits of these accessories is universally accepted by those who have used them. Use of the box angle principle may be seen in the machine tables and attachments used on various machine tools such as the radial drilling machine and the shaping machine. The box angle plate allows machining operations to be carried out on a job, bolted to it, in several different parallel or right angle planes simply by utilising the alternative locating faces of the "box". When the box is used in conjunction with an angle plate any desired angle between two machined faces may be obtained. In some machining procedures it may be found convenient to transfer the "box", from one machine to another, with the job set-up maintained.

The box angle plates that I have made (I made a pair) are dimensioned as shown in the drawing. You may wish to vary the sizes to suit your requirements. Unless for some special reason, such as mating with an existing accessory, I see no great practical advantage in making the overall dimensions "spot on". However, if making a pair then they should of course be made as near to identical as possible, with the tools at your disposal, as that obviously extends the flexibility of their use.

MAKING A BOX ANGLE PLATE

All of the machined faces of the box must be flat and square to those adjacent. If that relativity is achieved then parallelism is inherent. The machine tools used for construction may vary depending on those available in your shop. It could be a lathe face plate and angle plate combination. Lathe in the milling mode. A vertical mill and angle plate, or a horizontal/vertical mill. The accuracy of the finished job is of course largely a reflection of the accuracy of the machine tools used and also the cleanliness and diligence during setting up. It is doubtful that the engineer's square, used for setting up each face initially, would result in the same "squareness" gained by the machine slides (through use of a dial indicator). But then familiarity may be an advantage.

My box angle plates were made from iron castings. Some constructors may elect to use a fabrication of low carbon steel (possibly mild steel). It is a matter of choice and the order of choice is often influenced by reasons other than "most suitable".

In this article we have what can be considered three articles for the price of one. As well as the box angle plate, Ron Bernhardt of Australia, explains the requirements for making patterns from which castings can then be made. He also gives us some interesting, if technical, information on various types of modern day cast iron. This nicely follows on from that on the history of iron and steel in a recent issue of MEW.

Incidentally, the term "mild steel" as we use it is a very loose term and should only be used when referring to those low carbon steels which are known not to have chemical properties that allow a response to heat treatment. Hence the term "mild" by nature. Mild steel is a low carbon steel, but all low carbon steels are not "mild".

Cast iron in its various forms and grades is still the most widely used material for machine structures and housings. It is used in industry because of its relatively low cost, good casting characteristics, high compressive strength, wear resistance and good damping qualities. The term cast iron covers a wide range of alloys of iron, silicon and carbon having from 2 to 4% carbon and 0.25 to 3% silicon compounded with varying percentages of manganese, sulphur, phosphorus and in some cases one or more of the elements nickel, chromium, titanium, copper, molybdenum and

vanadium.

The properties of cast iron are regulated by the control of the amount, type, size and distribution of the various carbon formations. The important factors are:

- 1 - Casting design
- 2 - Chemical composition
- 3 - Type of melting scrap
- 4 - Melting process
- 5 - Rate of cooling in the mould
- 6 - Subsequent heat treatment

It is not advisable to specify cast irons by chemical composition. Different foundries use different ranges of composition to secure the desired properties, owing to the differences in raw materials, melting practices etc. In general the engineer who must be familiar with many metals need not know the intimate details of the production of each. Therefore, the method of producing the irons and their composition should be left to the discretion of the foundryman and his metallurgist, who are familiar with the many composition variables to obtain those

properties which the engineer desires.

The carbon in cast iron is of two types:

- 1 - Combined carbon as iron carbide
- 2 - Graphite, present as a mechanical admixture

The graphite is in the form of dispersed flakes occupying from 6 to 10% by volume of typical gray irons. These flakes impair the continuity of the matrix to such an extent that they exert a very pronounced effect upon the mechanical properties of the metal. An increase in the amount of graphite present in cast iron, such as an increase in the flake size or an unfavourable distribution of graphite, affects adversely the strength of the material.

Silicon has a powerful softening effect. Its presence in cast iron reduces the ability of the iron to retain carbon in chemical combination. With very little silicon, the iron retains all of its carbon in combination and white iron is produced. With about 3% silicon almost no carbon can be held in chemical combination. Manganese, chromium, molybdenum, titanium and vanadium promote the retention of carbon in the combined form (carbide stabilisers) and counteract silicon. Nickel and copper improve the matrix and increase the strength of the iron, but they do not lessen the amount of graphite present and keep the iron readily machinable.

There are the following broad classes of cast iron:

Gray cast iron

Is a cast iron that contains a relatively large percentage of its carbon in the form of graphite. The material has a distinctly grey coloured fracture. It may be plain gray cast iron or contain alloying elements offering from 138 to 414 N/mm square minimum tensile strength. Machinability is inversely related to the tensile strength and hardness, with the softer grades being excellent in this characteristic.

The endurance limit of gray cast iron is from 83 to 166 N/mm square. The elastic limit is close to its ultimate breaking strength. Typically it can sustain indefinitely a static load just short of its tensile strength without distortion or breakage. However, because of that ability it is essential that "in service" stresses be

known or alternatively a conservative safety factor should be employed. With static loading the ultimate strength of gray cast iron in tension is less than that shown in compression. The impact strength of most cast irons is low.

White or chilled iron

Is made by casting iron with some sections rapidly cooled by chills. The chilling of the alloy is so fast that the carbon is retained in the combined form throughout the chilled surface layer. "White iron" has a characteristic white colour because it contains no graphite. All of the carbon is in the form of cementite, either free or in lamellar pearlite. Another method of producing white iron is through adjustment of the chemical composition by keeping carbon and silicon low so that there is no free carbon throughout. That adjustment is made in an air furnace where low phosphorus pig iron and scrap steel are melted together. White cast iron is a very hard, brittle, wear resistant material.

Special process cast irons

These cast irons are produced by various patented control processes that achieve cast irons for specific purposes. Meehanite is the name given to a numerous group of such cast irons each having a different combination of mechanical and other engineering properties. Four general classification types are produced:

- a) - General engineering
- b) - Heat resisting
- c) - Wear resisting
- d) - Corrosion resisting

The tensile strengths of these irons vary from 173 to 380 N/mm square and up to 517 N/mm square with suitable heat treatment.

Spheroidal graphite/nodular/ductile cast iron

Is produced by the small additions of magnesium or cerium at the ladle stage. This cases the graphite content to take a

3&4: Components from a hermetic refrigeration compressor casting in ductile iron.

nodular or spheroidal form, well dispersed, throughout the material instead of the normal angular flakes. Ductile iron is not a single material but a family of materials. Its structure may be modified by alloys or heat treatment to suit particular applications. The advantages of this iron are high fluidity, excellent castability, high strength, high toughness, excellent wear resistance, pressure tightness, weldability and a higher machinability than grey iron. As cast grades of ductile iron have a tensile strength of between 414 and 724 N/mm square with an elongation from 1 to 10 percent depending on composition. Annealing reduces the tensile strength but increases the elongation to as much as 25 percent! Hence the name, ductile. Normalised and tempered specimens have a tensile strength of 620 to 827 N/mm square with an elongation of 2 to 5 percent. High strength pearlite irons, such as meehanite or nodular iron have the highest damping capacities (ability to absorb vibration) of all engineering metals. This is one important reason why cast iron is often selected for service as machinery bases and housings.

Malleable iron

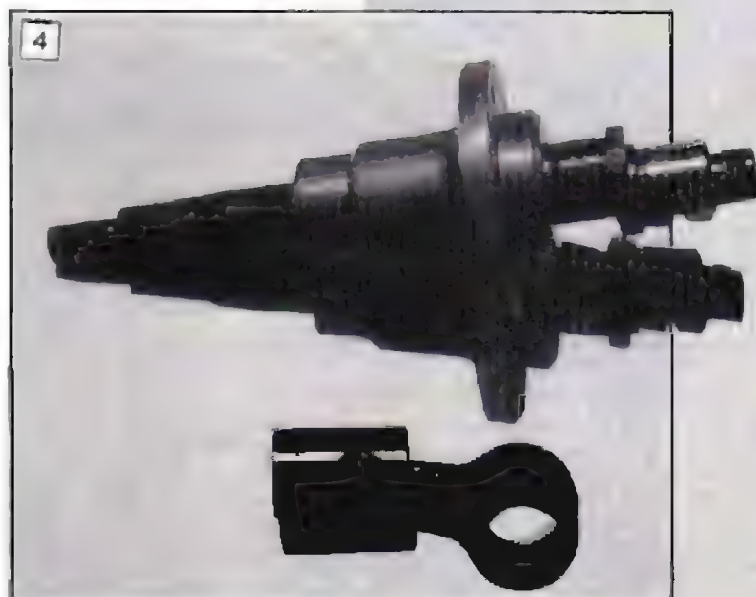
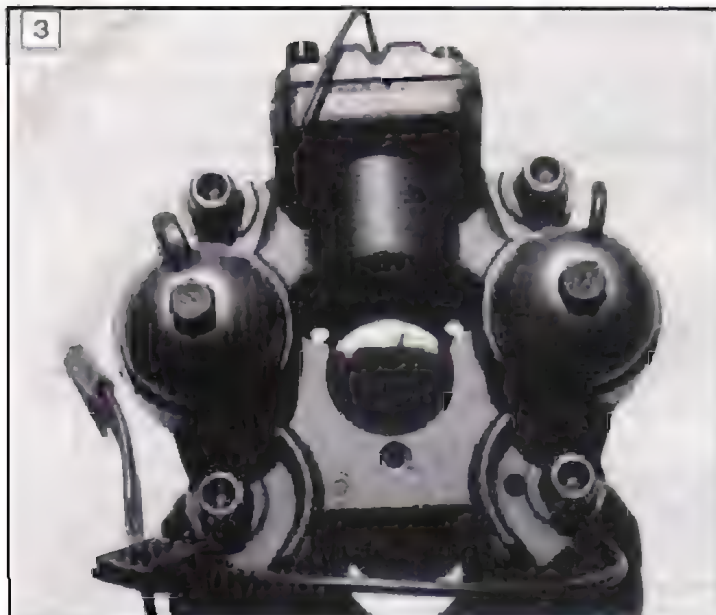
May be broadly divided as follows:

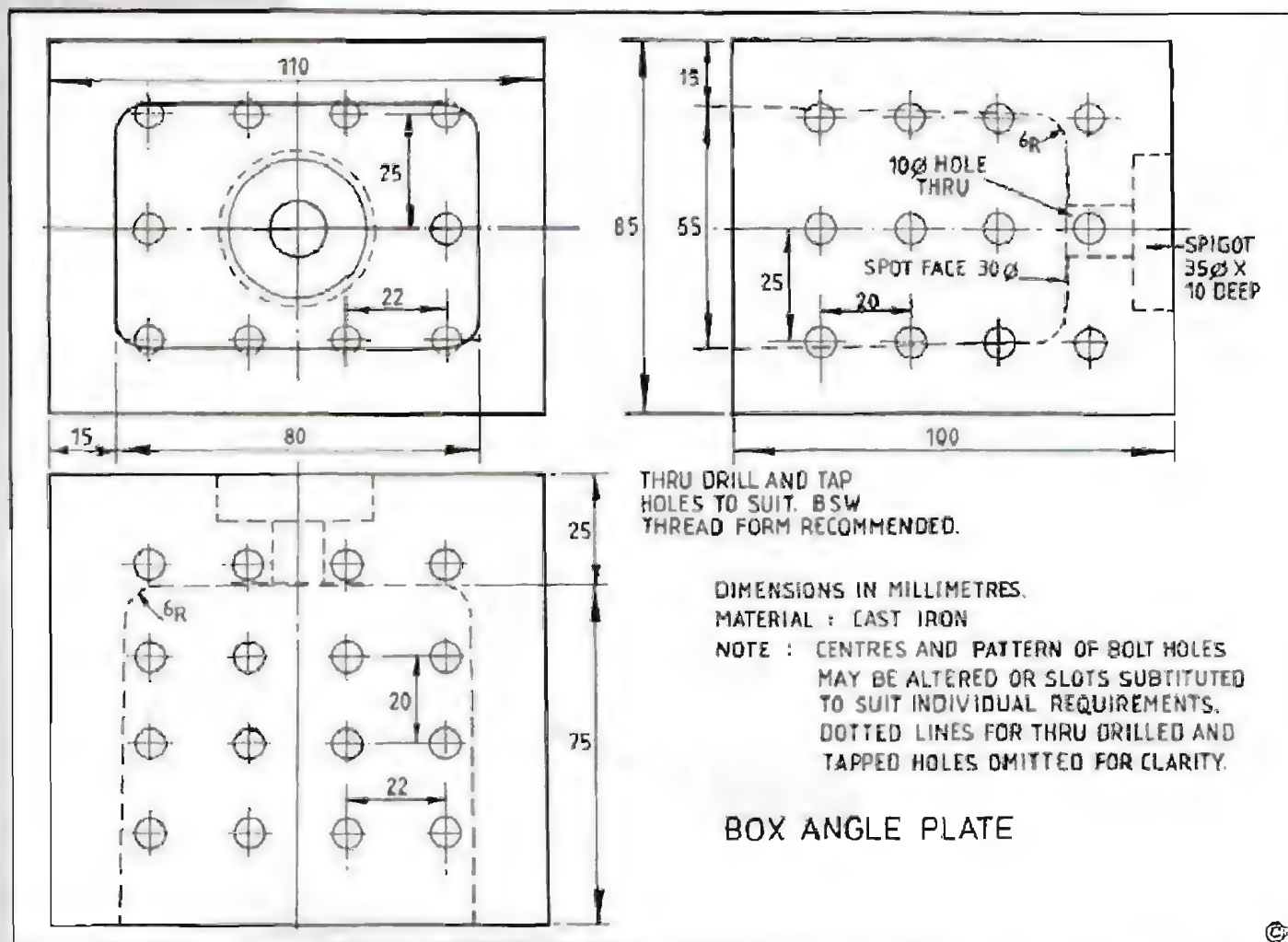
- 1) - Standard malleable irons
- 2) - Pearlitic malleable irons
- 3) - Special malleable irons
- 4) - Cupola malleable irons

The chemical composition of the white iron from which the standard malleable iron is produced falls generally within the following limits:

Carbon 2 to 2.7%
Silicon 1.2 to 0.8%
Manganese less than 0.55%
Phosphorous less than 0.2%
Sulphur less than 0.18%

Pearlitic malleable irons are made from a chemical composition similar to that of standard malleable iron together with additional alloys or so heat treated that some of the carbon in the resultant material is in the combined form. Special malleable irons consist principally of those with a high silicon content, those alloyed with copper, and those alloyed with copper and molybdenum. High silicon reduces annealing times. Copper used as an alloy addition increases the strength and endurance limit of the iron. The copper





molybdenum malleable iron is used for extra high strengths.

Cupola malleable iron composition is:

Carbon 2.8 to 3.3%

Silicon 0.6 to 1.1%

Manganese 0.4 to 0.65%

In the malleablising of cast iron by annealing, the castings are initially made as white iron of a suitable composition, which varies with the process of malleablising employed. Two such methods are employed. In Europe the casting are packed in an oxidising material during annealing. Subsequent to annealing the castings are known as "white heart" through the removal of some carbon. In the United States the castings are annealed while packed in inert material, such as ferrous silicate scale or slag. These malleablised castings, known as "black heart", consist almost entirely of graphite and ferrite.

The tensile strength of malleable irons vary from 345 to 768N/mm square. The standard malleable iron averages 390N/mm square tensile and is the most common grade in use. Malleable iron has excellent machinability and a high resistance to atmospheric corrosion.

Back to the box angle plate

Oh yes! About that box angle plate job. I used two sand castings in soft gray iron for my boxes. The sand casting of iron usually requires a pattern or set of patterns for use in the foundry for the making of the mould and any associated cores from which a casting can be produced to individual requirements. A number of materials are

now used, either in total or in part, for the manufacture of patterns used in the sand casting process. The two most common materials for pattern making are wood and metal. The durability and other merits of a metal pattern are not warranted in this case. Good old wood (a friend in need and a friend, indeed!) has served well both for the industrial and the home workshop.

There are a number of timbers which work well for this purpose, yellow pine, sugar pine and jellatong are common. I have used the harder grades of pacific maple successfully. Provide the wood works well, will not distort and allows a good smooth surface finish, without that furry surface which takes forever to seal, it serves the purpose.

Before making the pattern, consideration should be given to the several allowances which will need to be added to those finished dimensions of the box shown in the drawing, i.e. determine the dimensions of the pattern. The allowances to be made are:

A) Allowance for draft (taper) 2 per cent
1/4 in. per foot
2mm per 100mm

During casting, the closed end of the box section will be uppermost in the mould, and that face in that horizontal position will be the most likely section in the finished casting to contain blow holes, rubbish and slag. The other four sides which make the box section will be vertical and are the sections that need a taper allowance for draught on each side of the section. These sections are given this taper so that the pattern is more easily withdrawn from the

packed sand mould. I made my pattern with a taper of about 3mm on the section thickness, i.e. 1.5mm on the inside and the outside faces.

B) Shrinkage allowance about 1 per cent
1/4 in. per foot
1mm per 100mm

This allowance is made to accommodate the reduction in volume of the cast iron on cooling to the ambient temperature after pouring. It is given to all dimensions. Half of the allowance being added to each side of the section centre line. It is assumed in this instance that shrinkage will be uniform.

C) Machining allowance about 3mm (1/4 in.)
Better to allow a little more than "wish I had" particularly on that fault prone area, at the top, suggested earlier. This allowance is of course given only to those faces which are to be machined.

I suggest that the foregoing allowances are best added in the reverse order of event procedure, i.e. first the machining allowance, decided upon, should be doubled then added to the outside cubic dimensions of the finished box angle plate. Then add the allowance for shrinkage and finally for draught. Noting, as stated earlier, the way in which the added thicknesses are applied. One further point which I think is important is the need for a generous radius to all inside corners. It helps to ensure a clean pattern removal from the sand, reduces stress concentrations in the casting during cooling in the mould and also in service. Plastic wood or Plastibond are two of the many filler type materials available for that job. When finishing, an important point is a good smooth finish which is well



5: A "G" clamp. The frame is a malleable iron casting.

soiled against moisture. The pattern could be finish painted black. Ideally the pattern surface should be such that moulding sand will release readily without clinging. When you are satisfied with your pattern take it along to your foundryman and discuss your job with him. If he accepts your pattern, go home and work on that other project for a week or so.

When you get your castings into your workshop you will most likely have to remove the final traces of sand. This is often the last job for an old file before it becomes a scraper, woodturning tool or chisel etc. Finally clean up with a wire brush. Any remaining metal flashing can be removed on the grinding wheel. To check the casting for soundness, use a light hammer or a short length of steel bar end on, tap lightly all over each face of the casting particularly in the "suspect" area. This tapping should produce a uniform heavy metallic sound. Any change in sound will be easily detected where large voids are present under the surface. The smaller porous type blowholes, dirt and slag will have to be uncovered by machining, that is unless non-destructive examination facilities are available. The meticulous precision machine builder will now be concerned about the fact that the casting is "green", not in colour, but in age. If of concern, ageing may be given to the casting either by stress relief heat treatment (short term) or by leaving the rough machined casting/s out in the weather for a considerable period of time. (How long is considerable, can any reader be more specific? - Ed). During that "weathering" period regular skilful

casting that are not to be machined. If painted it looks better and won't rust, but just as important the paint seals the surface.

The first operation/s in removing metal should, as always, be to take a roughing cut over all of those faces which are to be machined ensuring that the "skin" of the casting is removed. This "roughing out all over" procedure is particularly important if the casting has not been stress relieved. Setting up and measurements should be taken from those surfaces of the casting which are not to be machined or the centre lines of unmachined holes. These operations help, (1) to relieve some of the surface stresses in the casting while at the same time revealing any flaws, hidden just below the surface, at an early stage and (2) to maintain a uniform wall thickness.

If more than one box angle plate is to be made and the machine to be employed has the capacity, then it would be well worth the investment of set-up time to machine the castings as a gang.

The drilled and tapped holes or slots intended for bolting on the box angle plate can be marked out and machined in as the next step following the rough machining of the faces. If the layout of these facilities is undecided then they may be left until a decision is clear. Tee slots could be an alternative, with the relevant web thickness

hammerings would be applied to the castings to encourage the release of locked in stresses (long term).

A coat of thick paint could be applied to the surfaces of the

increased accordingly, perhaps in one face only. I machined a female spigot in one face of one of my boxes. Then, when I bolt a matching button, which is a good fit in that spigot, to my webbed end angle plate I can rotate and clamp my box angle plate through 360 degrees. It makes a very versatile and rigid accessory to my machine tools.

6: Threaded pipe fittings made of malleable iron.



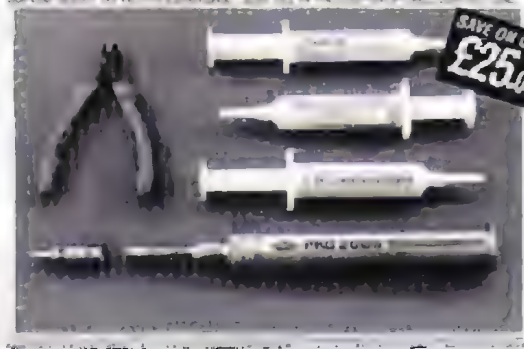
QUICK TIP

To produce drawings that can be taken into the workshop, handled with grubby, dirty hands and when no longer required, wiped clean, like a slate, I have used this way for quite a while. All that is required is a sheet of plasticard, readily obtainable from the local model shop, the drawing can be imposed upon the plasticard in pencil, then taken to the workshop and the component or what you have is made. When no longer required it can be wiped clean with a damp cloth and a little touch of cream cleaner (I like Jif), another advantage of using this method is that the plasticard is fairly rigid and can therefore be stood or propped in any convenient position.

Mr Scoggins

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BUILDING A GARDEN WORKSHOP

If you are considering building a new workshop in the coming summer period, now is the time to give some serious thought as to how it should be built. This article by M. Hudson is full of good common sense ideas to get you started.

My first workshop took shape a few years ago in a garage adjoining the house, but a single winter's rust deposits convinced me that all my precious tools would be better off indoors. Being a bachelor my decision was unopposed and set about converting the spare bedroom.

This was a very comfortable and convenient workshop but as I added more equipment and raw materials I worried that one day I would come home and find it all in the middle of the lounge floor below! The lack of rigidity also made it difficult to set the lathe up accurately so it was some

way from being the ideal set-up.

A great deal was learnt from this experience and, now that I have moved house it has been put to good use in the building of my latest workshop which has a solid concrete floor, is warm and dry in the garden. I am much closer to my dream workshop except that I have to step outside to get to it!

Design requirements

As I am likely to move again in a few years I wanted the building to be a harmonious feature of the garden which would add value to the property, but at the same time to be entirely suitable as a workshop.

Time was spent looking at commercial sheds and summerhouses but nothing seemed to fit my requirements of a workshop that looked like a summerhouse at a reasonable price, so I decided to design and build my own.

Apart from looking nice I wanted it to have a solid concrete floor, a framework which would take heavily loaded shelving, ample power sockets and lighting, good

natural light and for the whole structure to be damp proof and well insulated.

Position

Any new building must comply with the Town and Country Planning Acts as well as the Buildings Regulations. Although there are lots of "ifs and buts" it is fairly easy to arrange a building of this sort to fall into the "Permitted Development" planning classification. The Building Regulations also have a "Partially Exempted" class for small sheds and the like. However, potential builders are advised to have a word with their local Planning Department as the position on certain individual cases can be quite complex even though they appear to fit into the above two categories.

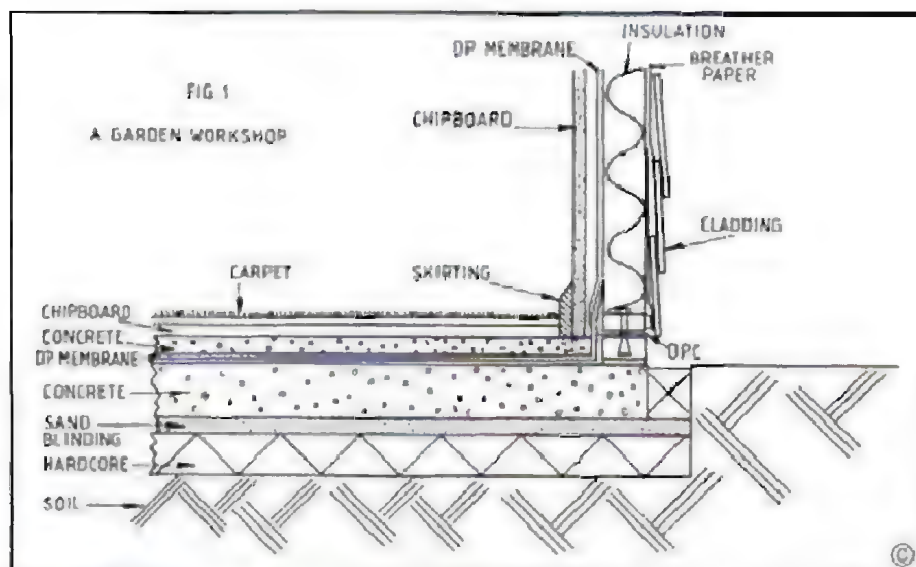
It was decided to situate the workshop 2 metres away from the rear of the garage in a corner of the garden. This kept it clear of the main house and made it convenient to access the garage where grinding and brazing facilities would remain. The position of the door and windows, which would cover most of the west side, was largely governed by the need to provide an

attractive view from the lounge and from the workshop. It was envisaged that the door would eventually open out onto a patio thereby completing the summerhouse effect.

The Concrete base

The base area (3.15m x 4.05m) would be made as large as could be accommodated by the land available and the height would have to be kept as low as possible for the sake of the neighbours.

Before I could make a start on the base a crazy paving path and a large apple tree had to be removed. It took a couple of days to shift it. An area was marked out with pegs and string a few inches larger than the final base and over 3 cubic meters of soil leaving a flat undisturbed bottom about 200mm deep. The crazy paving, an



Trial assembly of the side frames.

old bunker and part of someones broken garden wall (with permission) was broken up and used for hardcore which was compacted to a depth of 75mm. Sand blinding was laid over the hardcore and washed into the crevices using a hose. The formwork was set out to give a 100mm thick concrete slab the exact size for the base bringing the height level with the path around the house.

Once the concrete had cured a single course of bricks was built around the top of the base (which is exactly 18 x 14 standard bricks) and errors in squareness and level were corrected. Next, two layers of 1000 gauge PVC were sandwiched between the base and a further 75mm of concrete, forming the floor of the workshop. Finally a strip of DPC was cemented to the top of the bricks and the base was complete.

Even with a mixer the concreting was hard work and I would consider ready-mixed next time - even if it meant wheeling it around the back of the house in barrows.



The Timber structure

The woodwork was much more satisfying and started with a basic sketch of the framework to finalise the design and determine sizes and quantities. The framework is constructed from 50mm x 100mm studding at 610mm centres. A smaller size could have been used but 100mm gave a convenient wall thickness for Rockwool insulation and 50mm was a good width to aim a nail at while fixing the cladding. The 610mm spacing enables standard panels to be used without waste although the building industry seems to be



*Above: Assembled frames taking the strain!
Below: Frame with rafters in place.*

midway between imperial and metric (like everybody else). When my 2ft. x 8ft. T&G roof panels arrived they turned to be 8ft. long but with an effective width of 600mm!

All the components of the side frames were pre-cut, notched and painted with preservative to form a complete kit before nailing each side together separately using the base as "surface plate". To drive 3 six inch nails, dovetail fashion, into each joint and maintain accuracy is quite difficult. Here the hard work of notching each joint paid off.

Each frame was dropped into place over pre-fitted rag bolts and screwed to the next



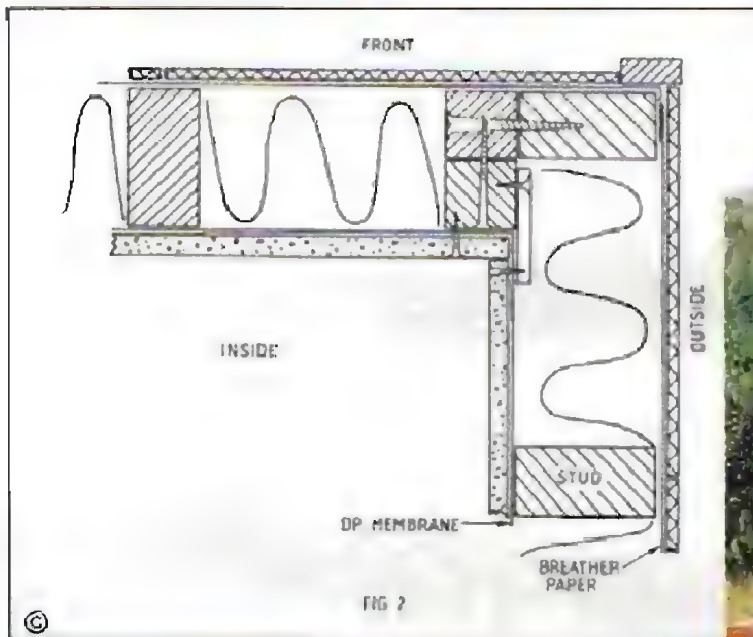
at the corners. It was now beginning to look like something.

The roof was finished next to give some protection for subsequent stages and was constructed from 150mm x 50mm rafters (with a 151mm fall) boarded with 18mm T&G chipboard and covered with 3 layers of heavyweight felt (the first nailed and the remainder bonded). Battens under the felt channel the water away from the sloping edges to the rear which projects 50mm beyond the cladding into a plastic gutter. The front edge projects 230mm to keep to drips away from the windows and door.

I discovered the side cladding ("wainy edge" seconds) at a timber yard while looking at ready made sheds. It is the key to the "summerhouse effect" which was trying to achieve and it is also incredibly cheap. The drawback is the time it takes to fix, as each piece has to be matched to next.

The cladding was coated with "Country Oak" preservative front and back nailed over a micro-porous vapour barrier which lets damp escape but keeps water out. This is especially necessary with this kind of cladding. The bottom section of each side was angled to keep drips away from the DPC and brickwork. Each vertical corner was finished with a regular strip to give a neat edge. Plywood soffits furnished with air vents allow ventilation to the roof space over the insulation ("cold deck" construction).

Frame detail.



Nailing cladding over breather paper. Roofing felt completed. Most of the cladding finished.



Screwing T & G roof panels in place.



The outward opening door was made with a similar cross section to the walls except that it was clad in vertical 12mm T&G to break up the front elevation. A modified Yale lock is fitted for security.

The final outside job was the provision of services and positioning the water butt. The butt is a handy supply of garden water but can fill to overflowing in a single night; it really needs a proper soakaway.

Fitting out

The workshop services are extensive. A plastic conduit is routed from beneath the eaves to the garage via the trench 500mm underground which carries a 45 amp mains cable, a 75 ohm coax and two 4 core phone cables. These all end up in the loft where the mains is connected to a separate fuse, the coax to an FM aerial, one phone cable to the phone via a BT connector and the other phone cable to the door bell. The two spare wires might eventually get used for an intercom or security alarm.

Inside, the walls and ceiling were lined with 100mm Rockwool insulation (leaving a 50mm air gap in the roof space) followed by a sheet of PVC sealed with tape at the edges and joined to the floor to the damp proof membrane.

All the electrical wiring was now fitted. It consists of a distribution unit, a 20 amp ring main supplying fifteen 13 amp double switched sockets set just above bench height, a lighting circuit for six individually switched 50 watt fluorescent lights, a thermostatically controlled spur supplying two outlets for electric heating and two speaker cables. It might seem like a lot of



Rockwool insulation held in place with paper strips.



Damp proof membrane fitted over insulation.



Wiring in position.



Interior panels complete.

QUICK TIP

One of the most useful workshop purchases I have made recently was in a caravanning store. A Far Eastern product, it was marketed under the name of B-B-Q Cleaner and consists of a plated steel scraper attached to a plastic handle which has a brass wire brush set into it. For getting accumulated filth off components which are in the workshop for repair or refurbishment it has few equals. I don't have a better source, but it is worth while keeping a look-out for a similar item.



Skirting boards in place. Painting and staining finished.

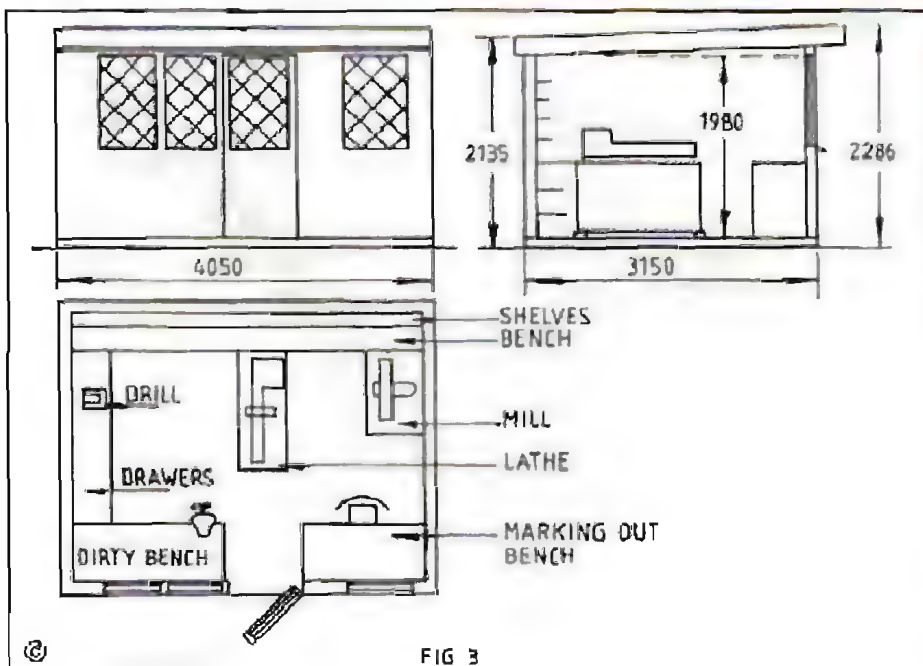


sockets and lights but I have found the layout to be extremely flexible.

The wall panels are 12mm chipboard painted with white silk emulsion. The skirting board, window frames and inside of the door are stained a complementary "Country Oak" in anticipation of the aesthetic tastes of future owners.

The window frames, which are set just above bench height, are fitted with double glazed units with a 20mm air gap to keep the heat in and isolate the neighbours from any noise. I made the frames non opening for simplicity so the door sometimes has to remain ajar for ventilation.

I have given up building benches, shelves and machine stands as part of the structure so the lathe, milling machine and "dirty" bench are now all free standing and the long assembly bench and shelves on



Two views of the finished workshop.

the far wall are supported by "Spur" type brackets. This approach means that I can set-up somewhere new with minimum effort. A number of "tool boards" from the previous workshop are now screwed to the left hand wall along a large pinboard.

Initially the bare concrete floor was found to be painfully cold to stand on. However a covering of carpet tiles over 12mm chipboard (with cutouts for the feet of the lathe cabinet) has cured the problem and I can now stand for hours in comfort (see below).

Thermal efficiency & condensation

It should be possible to keep condensation at bay within a damp proof structure provided that a steady temperature is maintained for both air and equipment. This means no sudden temperature changes. The west facing windows help by excluding the midday sun and all the insulation reduces the influence

of the outside temperature. The use of neat cutting oil (Shell Garia H) eliminates one source of water vapour.

With a standby temperature of 10 degrees Centigrade, and 15 degrees while I am working, I have no evidence of rust! Before monitoring the electricity consumption I made some rough calculations of the thermal efficiency as follows:-

Heat Loss = (Inside temp - Outside temp) x Area x U-value (Watts per hour)

Where U-value = Total Thermal Resistance.
Assume average winter temperature of -1 deg. C

Floor

Area = 11.16 sq.m.

Thermal resistance

- = 0.121 (175mm concrete) +
- 0.01 (2 plastic membranes) +
- 0.071 (12mm chipboard) +
- 0.04 (carpet) = 0.242.

U-value = 4.13

Heat loss = 11 x 11.16 x 4.13 = 507 Watts.

Ceiling

Area = 11.16 sq.m. (approx)

Thermal resistance

- = 0.037 (3 layers of felt) +
- 0.130 (18mm chipboard) +
- 2.5 (100mm Rockwool) +
- 0.005 (PVC) +
- 0.071 (12mm chipboard) = 2.743

U-value = 0.365

Heat Loss = 11 x 11.16 x 0.365 = 45 Watts

Walls

Area = 11.9m (sides) + 5.85m (front) +

7.46m (rear) = 25.22 sq. m.

Thermal resistance

- = 0.09 (12mm wainy edge)
- 0.01 (paper and plastic)
- 2.5 (100mm Rockwool)
- 0.071 (12mm chipboard) = 2.67

U-value = 0.375

Heat Loss = 11 x 25.22 x 0.375 = 104 Watts

Glazing

Area = 2.156 sq. m.

U-value = 0.8 (effective for 20mm air gap west facing)

Heat Loss = 11 x 2.156 x 0.8 = 19 Watts

This gives a total heat loss for 675 Watts (16.2KWA per day) with most of it going through the floor!

The actual consumption in December '91 was about 6KWH per day (208 Watts heat loss). This suggests an average outside temperature of about 6.5 degrees in December; near enough.

Floor insulation would have been a cost effective improvement but would have complicated the building of the base, as the aim was to provide a solid surface for the lathe.

Cost Breakdown

The work took about 400 man hours spread over 5 months with raw material costs as follows:-

Sand, aggregates, cement, bricks	£230
Plastic sheeting	£32
Breather paper	£48
Wood for framework	£236

Wainy edge cladding	£63
T & G roof panels	£77
T & G for door	£27
Internal panels	£85
Roofing felt & mastic	£132
Wood preservatives	£126
Electrical items	£230
Insulation	£63
Rain water goods	£54
Double glazing panels	£151
Mixer & skip hire	£63
Miscellaneous items	£114
Total	£1,731

This works out a approximately £135 per square metre of floor space.

Postscript

The system of burying the power cables under the internal cladding and amongst the insulation, is a good idea for both safety of the cable and for the final appearance. However, it should be borne in mind that cable in this situation will not cool so readily as that in the open, and will require to be sized accordingly. One size up should normally be satisfactory for power circuits whilst lighting circuits will probably be OK without any increase.

It should not be considered that, as you are unlikely to use any circuit continually, this can be overlooked, you will have no control over future users of the installation. If in doubt, consult an experienced electrician, or a copy of the IEE Regs. One final word of caution. With any outdoor workshop, particularly one built to this standard, you have a very valuable building. Do ensure that it, and its contents are adequately insured. Ed.

STOP!

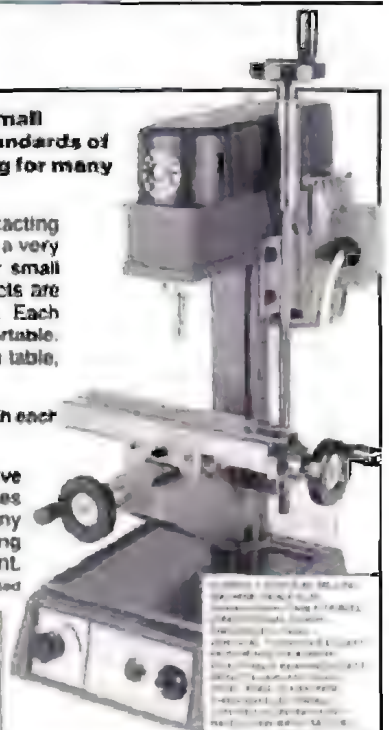
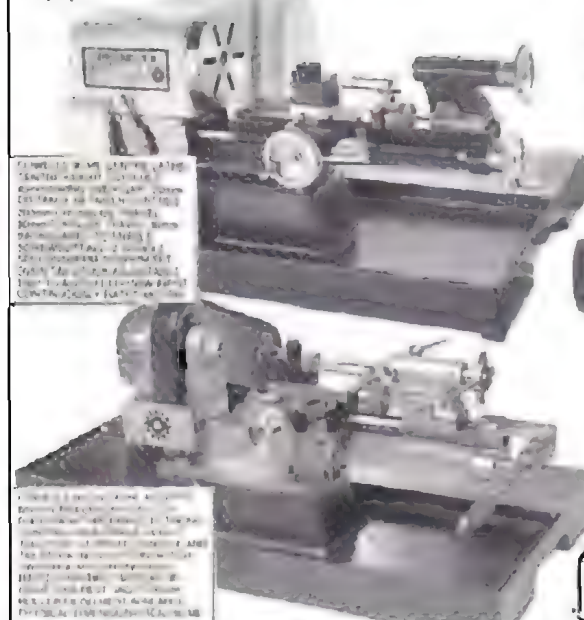
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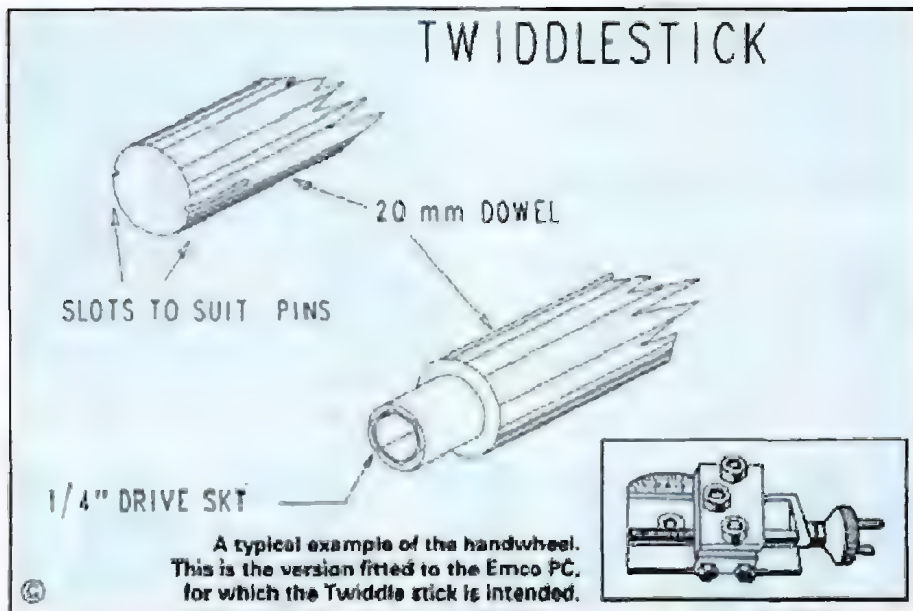
A twiddle stick

John Jennings comes up with this simple device, to simplify the operation of the top slide on smaller lathes.

A what? A dictionary definition of "twiddle" suggest that it is something you do with the thumbs of your idle hands. The gadget described is therefore probably more accurately described as an anti-twiddle stick in that it is intended to keep you busy. More seriously many things — such as the surface tension of water do not scale down and although we may buy and use small or miniature lathes they have to be operated by full size fingers. Many clock and watch making lathes solve this problem by using oversize but rather spindly versions of classic ball handles.

I have both a Unimat 3 and a Compact 5 lathe. With both the operation of the taper turning top-slide is often tricky particularly if a long slow taper which requires a good finish is required. The solution is the twiddle stick which enables you to use both hands to maintain slow continuous rotation. All you need is a short length of hardwood dowel adapted at the end to engage with the feed handle. Such a device can also be operated 20-30 deg. off axis.

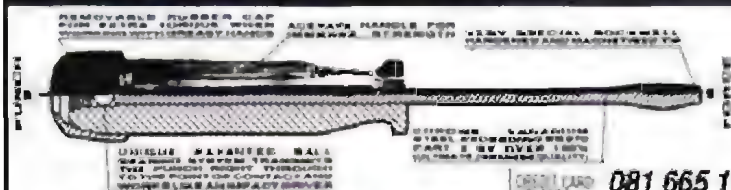
If a nut retains the feed knob in position as on the Compact 5 a suitable hexagon socket is attached to one end of a length of 20-25mm diameter dowel (a nut runner is a ready made twiddle stick!) I used a spare 1/4in. drive socket fastened with a No. 6 wood screw. The top-slide feed knob on the Unimat 3 is secured with a countersunk screw and an alternative link is required. The knob is however fitted with two pins that act as mini handles and two slots cut (I milled them with a 4mm stub drill) into the end of the 20mm diameter dowelling act as an effective drive linkage. You can combine both drivers in one, at opposite ends of a 6in. length of dowel. Give the dowel several coats of polyurethane varnish to help repel oil and swarf.



The two ends of the stick, with the actuating parts shown. Note the varnish coating on the wood in order to prevent the ingress of workshop dirt and grime.



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Most readers will have turned up a scrap of material to make a temporary hole gauge, then promptly thrown it away after completing the project. Why not start building up a range of hole gauges that can be retained for future use? By adopting the methods suggested in this brief article.

When boring a hole on the lathe to a close tolerance, the method adopted for measuring the hole will largely determine the accuracy achieved. The only ready made method for measuring the size of a hole being bored, is likely to be a vernier caliper. Using its



A set of Imperial gauges covering the range from 1/4in. to 3/4in. diameter.

HOLE GAUGES

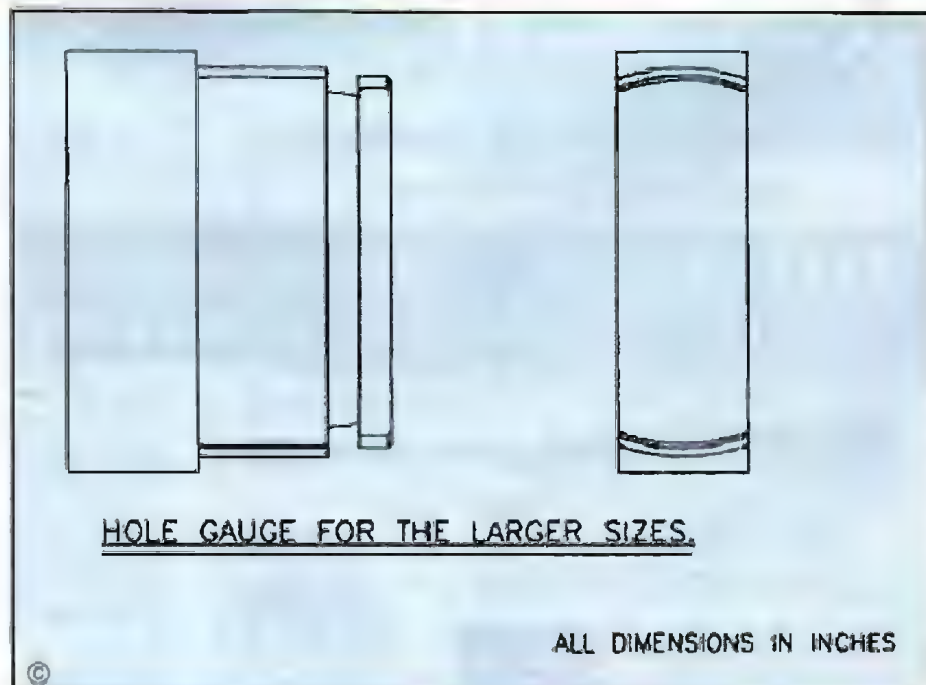
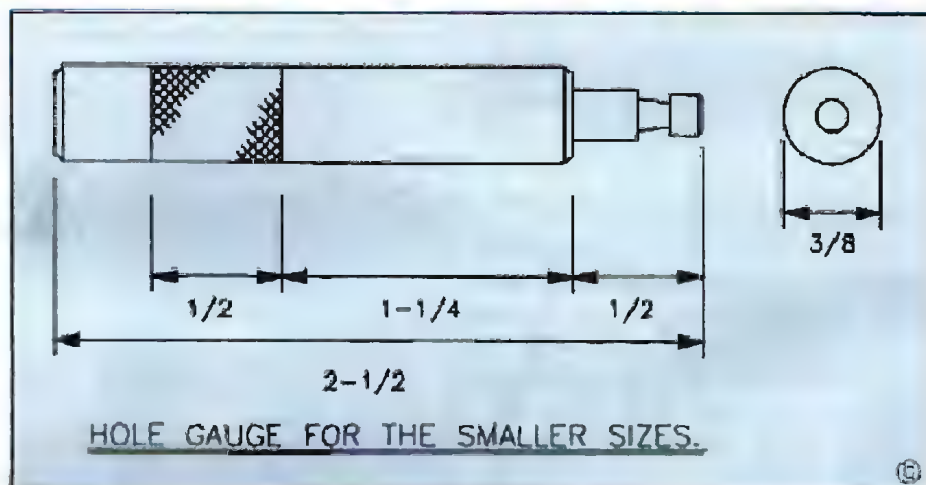
inside measuring capability should be reasonably accurate, however it is not easy to be confident of a spot-on result.

In industry when measuring holes which require to be made to a precise dimension with only a very small permitted variation, two gauges are used. These have sizes such the hole should be large enough to permit the smaller gauge to enter, whilst not being large enough for the larger gauge to enter. Because of this the gauges are known as Go and No Go gauges.

In this article the situation is that of boring a hole to a predetermined size, and not the requirement to measure an existing hole. When measuring a hole of uncertain size, possible methods are to use a vernier caliper, or if available and the hole is large enough, an inside micrometer. When measuring a hole being bored to a predetermined diameter, the simplest method for arriving at the correct dimension, is by use of an already made hole gauge.

To achieve a very precise dimension to the finished hole will require finishing cuts to be very fine. This can result in the need to make many repetitive fine cuts, due to it being uncertain how close the bore is to the required result. So as to limit this uncertainty a two-stage gauge is used. With the smaller diameter being 5 thou. less than the required size, this will give an early indication that the hole is approaching the required dimension. The 1/2 inch chamfer is also helpful as an approximate third stage. Perhaps this form of gauge should be called a Go and a Go-Go gauge.

To minimise the amount of metal used and also the storage space required, the gauges proposed are used with a removable handle. The gauges are drilled and reamed 1/4 inch diameter, and to make these fit firmly to the handle, this is made with a spigot 0.1248 inch diameter, but then tapers to a larger diameter as can be seen in the drawing. This taper enables the gauge to be pushed onto the handle where it becomes captive.



A similar handle is made but without the knurl, the purpose of which is for it to be used as a stub mandrel in the lathe when turning the gauges to size. As there is no requirement for concentricity, the mandrel can, if required, be retained for use again at a later date.

Whilst it is probable that one would start off by making a range of standard sizes, say in $\frac{1}{16}$ inch and/or 1mm steps, the probability is that at some time a requirement will materialise for a non-standard size. The success of these gauges will in part be dependent on their immediate availability. Whilst specials can be made only as the requirement occurs, having some blanks and the mandrel available will greatly increase the possibility of the system being used in these cases.

Achieving the required accuracy

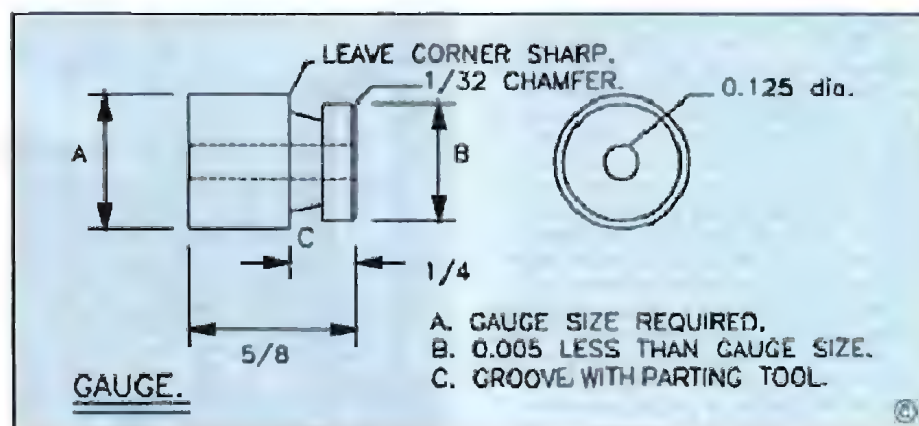
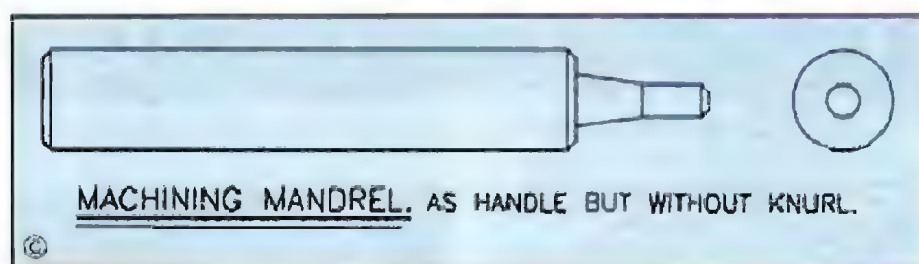
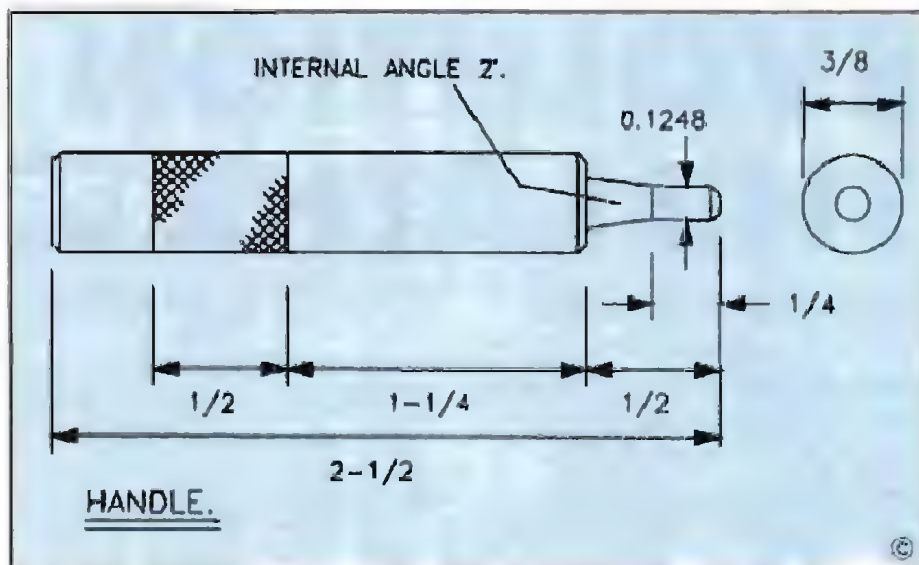
To achieve the accuracy required, probably better than $\pm 0.0000-0.0001$ in. will require very precise control over the position of the cutting tool. This is best obtained by setting the top slide to an angle of about six degrees, and using this to feed the tool into the work. By this method control over the diameter of the gauge will be much easier, giving $\frac{1}{16}$ thou. off the radius of the part being turned, for a 1 thou. movement of the top slide. Alternatively even more precise would be to set the top slide to $\frac{1}{2}$ degree, in which case a 10 thou. movement would give $\frac{1}{16}$ thou off the radius.

To ensure that the lathe tool will reliably make cuts of a tenth of a thou. it is essential that the tool is honed to give a very fine edge. Also of equal importance is that it is not above centre. finish will also benefit from the tool having a generous radius, the radius will though prevent there being a good sharp leading edge to the full diameter portion of the gauge. To create this sharp edge, use the parting off tool to make the groove shown on the drawings.

Smaller and larger sizes

For small sizes, probably less than $\frac{1}{2}$ inch diameter, the gauges will require to be made with integral handles. For larger sizes, say over 1 inch diameter, the method of using a flat piece of bright mild steel is adopted. These should be around $1\frac{1}{2} \times \frac{1}{4}$

A larger gauge, this one is 2in. diameter.



inch for the sizes from 1 to 2 inches, and $1\frac{1}{2} \times \frac{1}{4}$ inch for the larger sizes. These types can also be seen in the accompanying drawings.

Do make some blanks for later use, and also retain the mandrel so that other sizes can be made rapidly when required, so as to achieve maximum use of the arrangement.

Storage

It would also be a good idea to make a wooden block with pins for the gauges and holes for the handles. This would enable the parts to be stored without fear of damage, as small burrs on the leading edge could cause errors in their

use. If you choose to make both metric and imperial sizes make some distinguishing mark on one series to enable the two to be kept separate easily. This could be done by including a small spigot, say $\frac{1}{16}$ inch diameter and $\frac{1}{2}$ inch long on the front of all Imperial gauges.

QUICK TIP

A Sheet of white melamine faced chipboard the full length of the lathe and about 18in. wide resting in the swarf tray and leaning against the wall has a four-fold benefit:

- 1) Being white it reflects diffused available light onto the work.
- 2) It acts as a splashback preventing oil/coolant splatter marks on the wall and can be wiped down easily.
- 3) Being rested in the swarf tray it stops small items getting lost down the back of the lathe and keeps all the swarf in the tray.
- 4) The large white surface makes the best background to look at work against.

EVOLUTION OF THE LATHE **PART 1**

Don Unwin provides, in this article, a fascinating insight into the early days of the lathe, and how its evolution has contributed to the lathes we have today in our home workshops.

Whilst you have been watching your lathe during a long self-act sliding or surfacing job have you ever thought about the ancestry of your faithful machine?

The origins are lost in the mists of antiquity but generally believed to have descended from that first 'machine tool', the bow drill, **Fig 1a**, known to have been used in Egypt about 4000 BC.

Drills were made of copper or bronze and only ivory, wood, bone and other materials being worked. The bow lathe, **Fig. 1b**, in which the work was mounted between centres and rotated in the same way as the bow drill, probably appeared about the second millennium BC; as can be seen on an Egyptian mural and also in Mesopotamia, from where the knowledge gradually moved westwards to Europe. There are many carved representations, manuscript illustrations and examples of turned vases, chair legs, bowls etc.; the earliest dating from the first century BC produced in countries of the Mediterranean region.

As one hand was needed to operate the bow there was only one hand to hold the tool which could only be applied to the work when it was rotating in the forward direction and withdrawn on the reverse



Fig.2: A pole lathe, from a drawing of about 1395 (*Mendelesches Bruderbuch*).

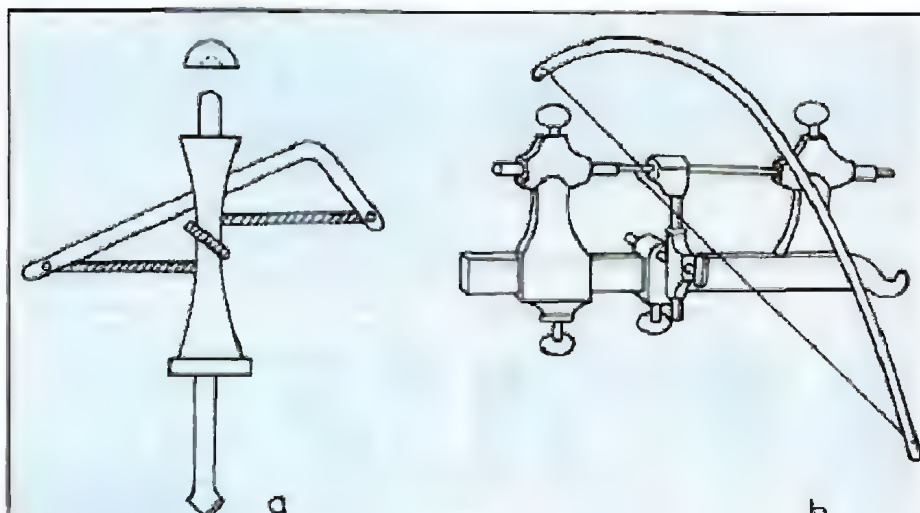


Fig. 1a: An early Egyptian bow drill.

Fig. 1b: A clock makers' bow lathe, this example dating from the 18th century.



Fig. 3: A later pole lathe, this example from about 1700 (*Moxon, 1685*).

stroke of the bow. This required considerable skill and made precision work difficult. Even so some clock and watch makers were using the system until recently - maybe some still do. However this limitation was solved in Mesopotamia before 1000 BC by the development of the pole lathe, **Fig.2**. A string was wrapped one turn around the work which was still

mounted between centres as before. One end of the string was fixed to the end of a springy wood pole mounted above the lathe and the lower end fixed to a hinged plank forming a treadle below the lathe. This was pressed down for the cutting stroke and returned upwards by the springy pole. Although the work still rotated backwards and forwards the turner

now had both hands available to control the tool. **Fig.3.** Again the pole lathe has been used in very recent times in this country by the chair bodgers producing wood chair legs and rails for the furniture trade and they are still widely used in developing countries.

By the 8th century BC iron (not steel) tools were replacing the bronze ones. Then about 500 BC the hardenable steel iron evolved by the Chalybes tribe some 1000 years earlier was gradually becoming available for making cutting tools, enabling the turning of metals possible in the addition to the usual soft materials.

It was the instrument and clock makers, stimulated by man's desire to know about the visible heavens, who became the first turners of metal with anything approaching precision in the 13th century AD.

The need for unidirectional motion was satisfied about 1340 by the invention of the crank and treadle, driving at first by a belt on to a pulley fixed directly on the work. Soon the 'end wheel' or 'mandril' lathe with a belt driven mandril in bearings appeared but with the work still mounted between centres. A crude form of chuck, a cup with 4 setscrews in the rim and the faceplate followed but the tool was still



Fig. 4: A treadle driven mandril lathe from the same period as the pole lathe above. (Moxon, 1685).

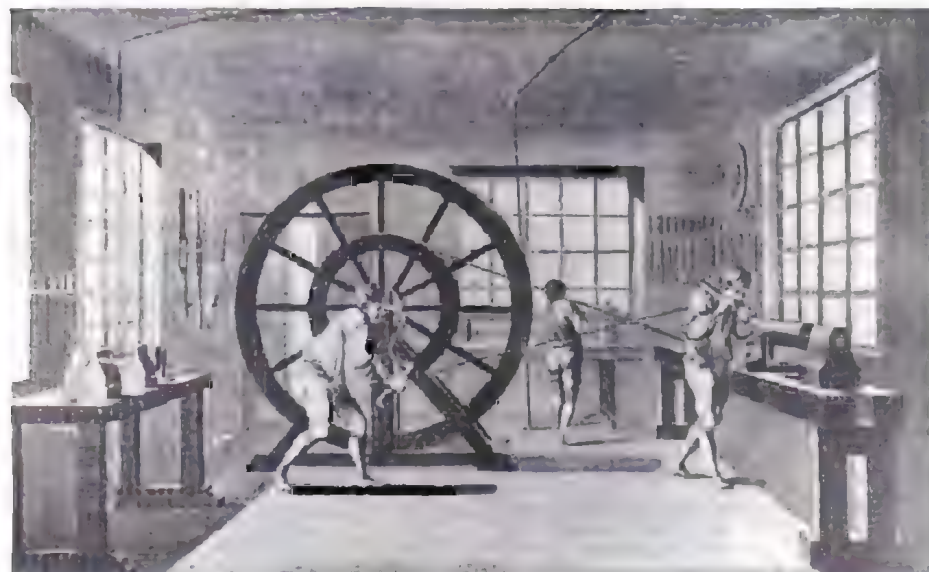


Fig. 5: An example of a hand crank driven lathe, c.1771. (Diderot).

Fig. 6: A hand crank driven lathe installed in the Cambridge Scientific Instrument Co. first workshops in 1882.



held by hand on a rest, **Fig.4.** The other method of obtaining unidirectional motion developed about the same time usually on larger machines, was a large flywheel fitted with a handle and rotated by a separate operator or operators and coupled to the lathe by a belt. **Fig.5.**

This method was still being used by Robert Flucher and Horace Darwin in the first workshops of the Cambridge Scientific Instrument Company in 1878. A gas engine was not installed until 1883 and even then only to drive the larger machines, treadle still being used to drive the smaller machines, until 1895. **Figs.6 and 7.**

Technical developments in the 16th century were mainly on ornamental and medallion copying lathes, Besson in 1569 illustrates such a machine. By the 18th century the ornamental turning lathe had become very popular with the rich amateur gentry.

The relatively small capital investment necessary enabled the 'mandril' lathe treadle or flywheel driven to be developed by 1700 into a machine capable of the precision work scientific instrument and clock makers were able to turn out, whilst the large machines remain very crude indeed until the early 19th century.

Screw Cutting

The Frenchman Plumier in the first treatise on the lathe work which he published in 1701 describes many innovations including the split soft metal bearings and coned bearings or a combination of the two. He also illustrates the early mandril lathe with means to cut the short screw threads being demanded by the scientific instrument makers. The first types had a single threaded portion on the tail end of the mandril into which was wedged a piece of wood to form a nut. As the mandril was rotated it advanced forward thus allowing a fixed but hand held chaser like a tool to cut a similar pitch thread on the work. **Fig.8.** The next development was for the mandril to have a number of different pitch portions and



Fig. 7: Looking across the Cambridge Scientific Instrument co. Workshops, the second shop viewed in 1884. The hand crank drive can be seen in the centre distance.

means to wedge the appropriate 'nut' into the chosen pitch **Fig.9.**

It is interesting to look at the early development of the screw threads – your lathe would be a very crude machine without them! – and with the Editor's permission I will deal with the subject in a future article.

Slide rests

Lathes up to this period were constructed mainly of wood with a few iron or brass plates and components.

The first mention of a slide rest is in a manuscript of 1480 but they were not in general use until much later and then mainly by the instrument and clock makers.

Diderot in his treatise of 1777 shows slide rests with dovetails, gib strips and screws indicating that by this time their use was quite well known. **Fig.10.**

It must not be forgotten that the development of machine tools was influenced greatly by the improvements in the quality and production of cast iron, wrought iron and steel in the second half of the 18th century. These developments together with the invention of the steam engine and cheap transport on the new canal system stimulated rapid industrial expansion and with it the need for machine tools.

The invention of the steam engine with the need to bore the cylinders and other turned parts stimulated the development of

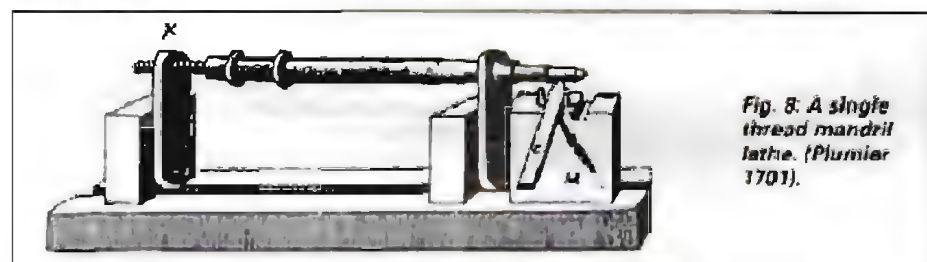


Fig. 8: A single thread mandril lathe. (Plumier 1701).

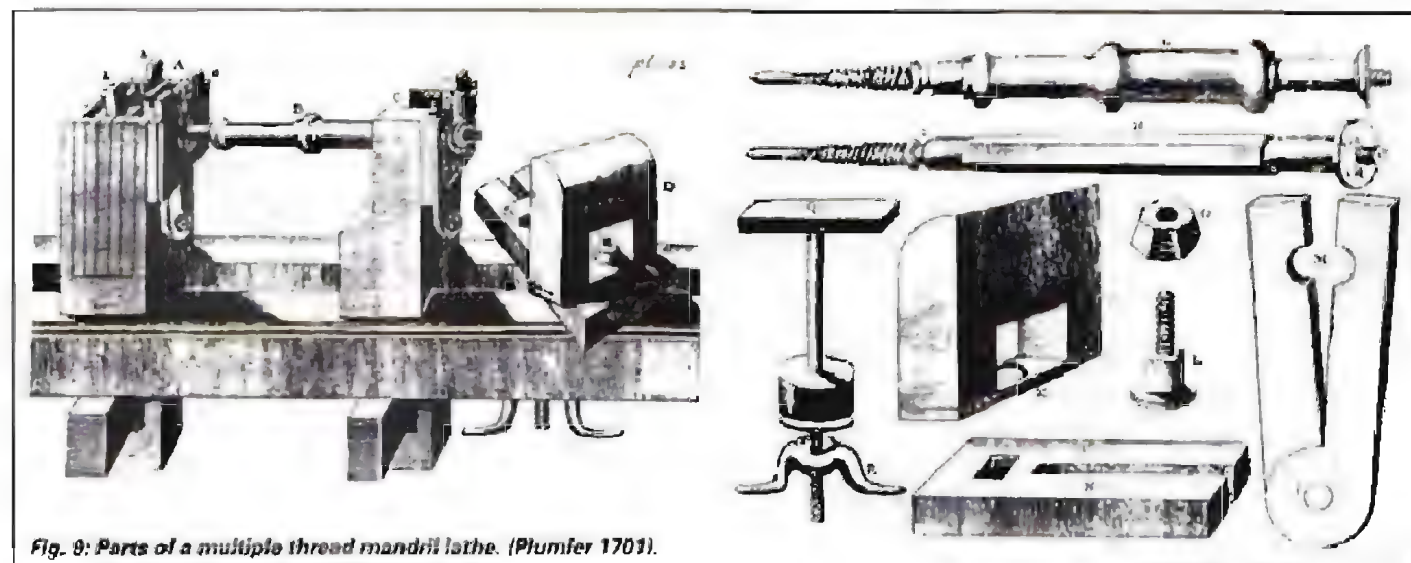


Fig. 9: Parts of a multiple thread mandril lathe. (Plumier 1701).

larger machines although needless to say it was the need to bore large guns that encouraged the development in the first place. The first large machine tool was the boring machine, later to be adapted to bore the cylinders of the new Watt steam engine.

Another important metallurgical invention which helped the machine tool industry was Benjamin Huntsman's successful production of crucible cast steel on a commercial scale in 1758. Up until Huntsman's process hardenable carbon steel was expensive and of very variable quality.

From 1750 onwards the lathe advanced rapidly. In 1750 Antoine Thiout devised a tool holding carriage moved by a screw and means to vary the pitch being cut, not by change wheels but by a system of levers. These introduced errors due to angularity which were negligible on the short threads being cut, **Fig. 11**. 1768 saw Jacques Vaucanson, a French textile machine maker, producing a drilling machine and a lathe for special purposes both all iron with carriages running on triangular shaped bars and traversed by lead screws. They could take work 300mm diameter by 1m. long

Henry Maudslay

Joseph Bramah, inventor of the hydraulic press and many other innovations, enters the scene. Bramah's influence on the lathe was not direct but in 1789 Henry Maudslay; baptised Maudslay but used Maudslay himself; joined him, soon to become his foreman. Bramah encouraged Maudslay's innovative abilities and outstanding craftsmanship to develop special machines to produce his inventions. One of these was a spring winding machine in which the pitch was controlled by a lead screw and change wheels, a reel of wire being mounted on the carriage instead of a tool. Even so the lead screw and change wheels were not new, Leonardo da Vinci illustrating them around 1500 and Samuel Bentham describing them in his patent of 1793.

As Bramah refused to increase Maudslay's wages of 30/-(£1.50) a week he left in 1797 and started up on his own. From the beginning he set very high standards of accuracy and quality and before long made his first lathe. It had triangular bedways and a cross slide carrying the tool. Oddly the headstock was on the right hand end of the bed, a rare example not seen since Plumier in 1701 or repeated until 1850 on special purpose lathes. Different pitches were obtained by changing the lead screw. Later in 1800 he made his second improved screw cutting lathe this time with change wheels to enable the pitch to be altered. He used two or three different methods for making the lead screws and the many other precision threads his works produced which I will discuss in the later article.

Five years earlier in 1795 the Frenchmen Senot and Jean Fortan had made for a special purpose a lathe with lead screw, change wheels and a back steady for supporting long work. This was relatively unknown and Maudslay was not aware of it.

Although the invention of the slide has been attributed to the French in 1717 and even earlier, it was used by Bramah, Bentham and Brunel in England and Silvanus Brown in America, whilst David Wilkinson of Pawtucket was granted a patent in 1798, and instrument makers and to some extent clock makers had been using it in a crude form, it was Henry Maudslay who designed and made it a practical device. Through his influence he popularised 'Maudslay's Go-cart' as it was called by contemporary mechanics and from which the modern slide rest is the linear descendant. **Fig. 12**.

He also standardised the threads used in his works and made taps and dies to produce them whilst the machines he made were also mainly for works use although he did make a £200 lathe, selling a few. However his high quality work attracted four other engineers who were to have a great influence on the machine tool industry.

In 1814 Joseph Clement joined Maudslay as chief draughtsman where he designed some of the large marine engines for which Maudslay, Son & Field were renowned.

By 1817 Clement had also started his own small workshop which remained small throughout his life. He was responsible for many detail improvements to machine tools and to screwing taps and dies. Perhaps his main contribution was in 1827 with his ingenious facing lathe fitted with a mechanism to vary the rotational speed to

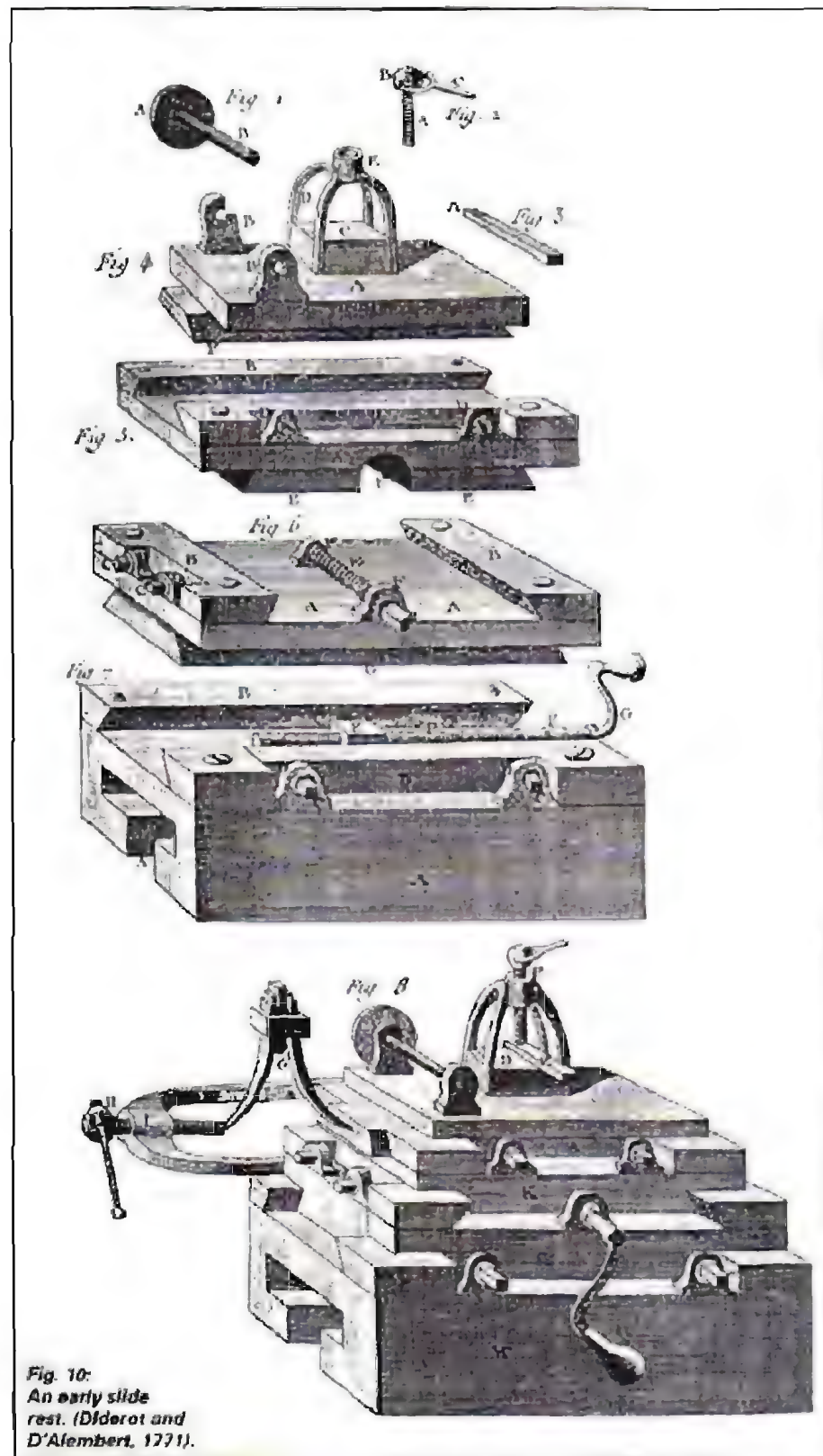


Fig. 10:
An early slide
rest. (Diderot and
D'Alembert, 1771).

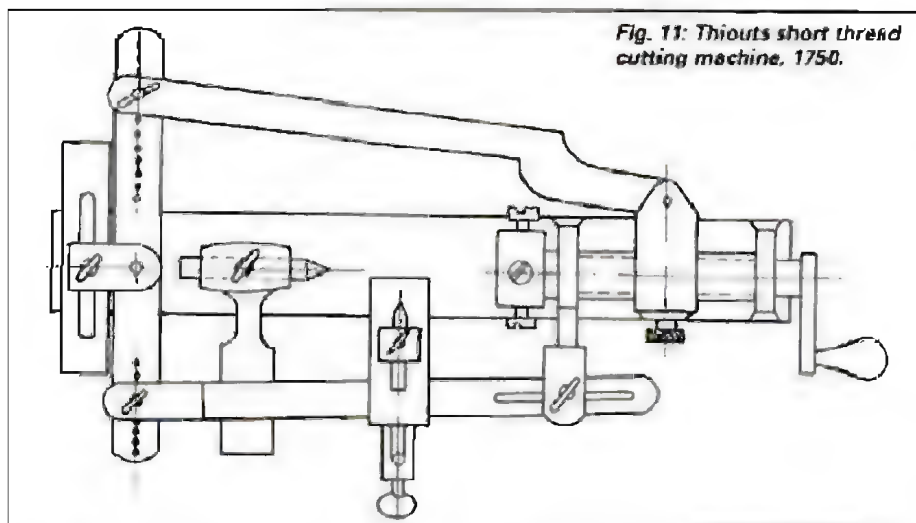


Fig. 11: Thouts short thread cutting machine, 1750.

maintain a constant cutting speed as the tool traversed across the work face, a feature to become common on capstan and turret lathes at the end of 19th century.

Richard Roberts had also worked for Maudslay as a turner and litter before starting up on his own in Manchester in 1816. He made a good back geared self acting lathe in 1817 and his second lathe had means of indexing for cutting multiple start threads and a quick withdrawal tool slide. By 1821 he had 12 or 14 mechanics as well as 3 men paid 11/- (55p) a week to hand turn the machines. As well as introducing plug and ring gauges to ensure interchangeability, many improved lathes, a gear cutting machine, a screw cutting machine and the first drilling machine left his works.

Alexander Nasmyth

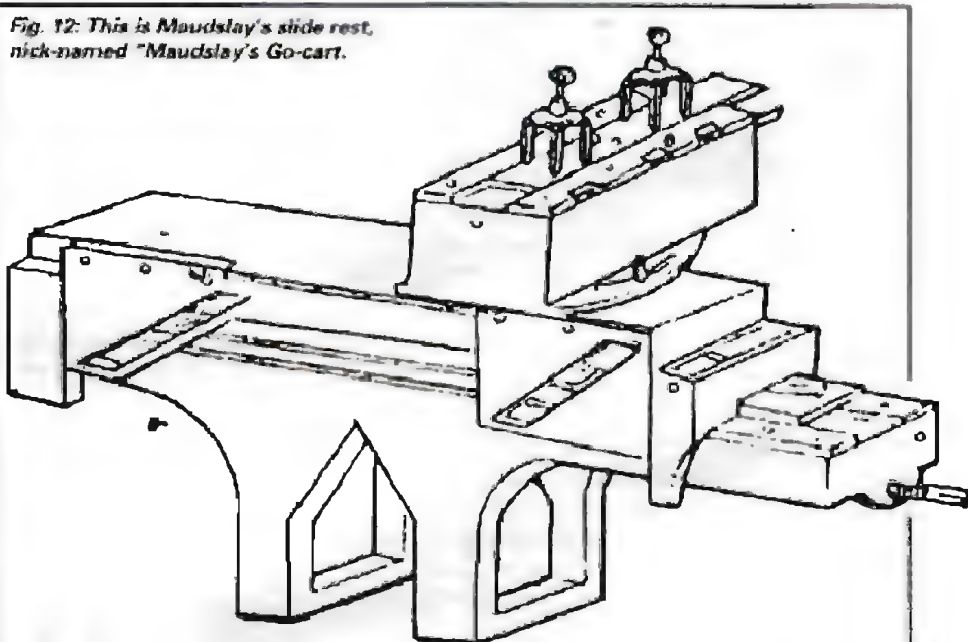
In the early 1800s there was in Edinburgh a portrait painter, Alexander Nasmyth, who was also an accomplished amateur engineer. Working in his father's workshop his son James made a successful steam engine and boiler. Leaving Leith in 1820 father and son set sail for London to see Maudslay, who was so impressed that he immediately took young James Nasmyth as his personal assistant. When Maudslay died in 1831 Nasmyth returned to set up his own small business using his father's treadle lathe to make large lathes and other machines from castings which Joshua Field, Maudslay's partner, had allowed him to make before he left. Later he moved to Manchester where his firm made many large machines including his famous steam hammer. Among the lathe improvements for which he was responsible was the tumbler reverse on the lead screw and self act drives. Fig. 13. Nasmyth was a great believer in the 'self-acting' machine as a means of employing semi-skilled labour and his 'ambidexter turning lathe' of 1850 is an example. Fig. 14.

Another machine tool builder of this period, but not from the Maudslay stable, was James Fox, a parson's son who started in Derby making textile machinery about 1812. By 1814 he had made his first planer and many lathe improvements including carriage traverse by rack and pinion separate from the screw and the now conventional inverted vee and flat slide ways, Fig. 15. Most of his machines were for use in his textile machine making business.

Charles Holtzapffel

Also of the period was Charles Holtzapffel, 1806-1847, the well educated

Fig. 12: This is Maudslay's slide rest, nick-named "Maudslay's Go-cart".



son of a German engineer, who came to London in 1784, became naturalised British and in 1785 produced a treadle mandril lathe with 10 threads, a 3 step pulley but a wood bed. Charles became a leading and influential machine builder, particularly of complicated ornamental lathes of high quality. With his son John they published in 5 volumes a valuable work called *Turning and Mechanical Manipulation* which became the ornamental turners Bible and covers a much wider field than the title implies.

Joseph Whitworth

Maudslay was superseded as the dominant machine tool engineer by another of his ex-employees, Joseph Whitworth, who had also worked for Holtzapffel and Clement before starting his own business in Manchester in 1833. Whitworth was a great improver and was responsible for the auto feed in 1835,

although Clements had made a more complicated system 10 years earlier, the strong box bed construction, two slide rests on a long bed, his millionth of an inch measuring machine and of course his standardised screw threads announced in 1841 and in general use by 1860.

At this point we will take a look at the American scene where machine tool development took a different route

Eli Whitney

In 1798 Eli Whitney undertook to supply the American government with 12,000 muskets, a contract which was not fulfilled for 8 years. The success was his adoption of the system of interchangeability which he popularised, although he did not invent it. From 1815 onwards it was a condition of all government contracts. Others, including Samuel Colt, also became involved in small arms production. Colt was very good at choosing men and his superintendent Elisha Root, 1808-1865, was probably

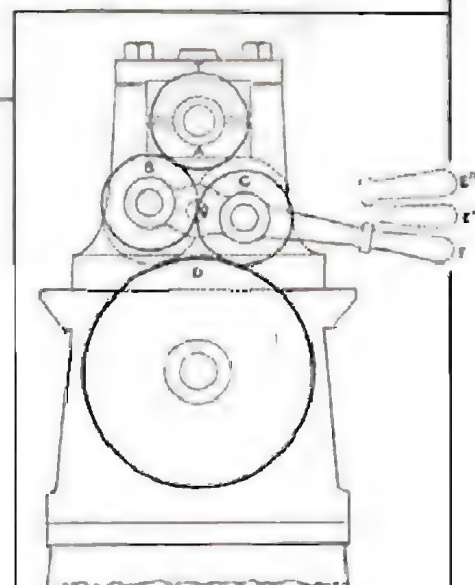


Fig. 13: James Nasmyth's tumbler reverse for the lathe traverse, 1837 (James Nasmyth, Autobiography, 1883).

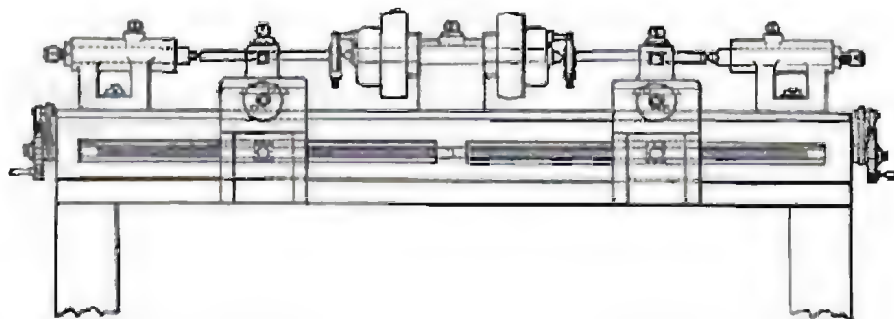
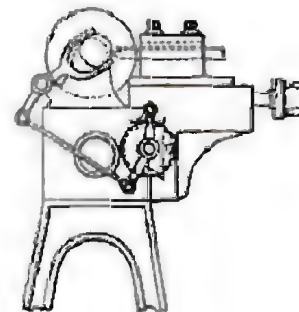


Fig. 14: Nasmyth's Ambidexter lathe. (James Nasmyth, Autobiography 1883).



responsible for more specialised machines gauging techniques than anybody at that time. In his works all hand work including burr removal was virtually eliminated.

One interesting early example of mechanism for interchangeability was the special lathe of Thomas Blanchard in 1818

for turning the irregular shaped wood gun stocks to fit the iron lock plates.

In 1853 a group of engineers including Whitworth toured America to look at the system and they recommended that it should be introduced in the new government Enfield Small Arms Factory.

Arising from this some 157 American machines were installed. However, although Whitworth strongly recommended the 'American system' it was almost 50 years before it became generally accepted by British industry.

Even so at that time the American general purpose lathe was very inferior to the British machine, some still having plated beds, but in the field of repetition work the picture was reversed.



Fig. 15: This is a James Fox lathe of 1817, photographed at the Birmingham Museum of Industry.

The first capstan lathe

Stephen Fitch in 1845 made the first turret lathe, the type called capstan in Britain, to produce percussion cap screws. This had the turret axis of rotation horizontal, parallel to the lathe bed. Robbins & Lawrence, influenced by Frederick Howe, 1822-1891, a prolific machine designer of the time, introduced the superior vertical axis turret about 1850. In 1871 Edward Parkhurst had invented the collet chuck with closing mechanism which could be operated while the machine was in motion. This led to the automatic screw machine, an early one designed by Christopher Spencer and made by Pratt & Whitney in 1873 had a 'brain wheel' or cam drum to operate the various movements. Spencer started the Hartford Machine Screw Company which, in addition to single spindle machines, Fig. 16, made three and four spindle automatic screw machines. Although called screw machines they were used on any small turned parts and when adopted in Britain called automatic lathes or 'autos'.

Brown & Sharpe's first machine made for sale in 1852 was a Howe influenced turret lathe, again the type called capstan in Britain, with the turret axis vertical, Fig. 17.

Baxter D. Whitney made a lathe in 1854 with the bed having 3 vees, a semicircular front, the saddle running on this and the back vee with a shoe and adjusting screw giving a rising tool rest as was popular on American lathes. The saddle was weighted, not held down on the bed by gibs, also an American feature retained until the end of the 19th century, and the backgear was mounted below the headstock. American lathes were lighter than their British counterparts, often using softer irons and designed for a shorter life compatible with the American ideas of rapid development and replacement.

In the next article we will look at the development of lathes, especially those connected with our hobby activities.



Fig. 16: The Hartford Automatic lathe, from the same Museum.

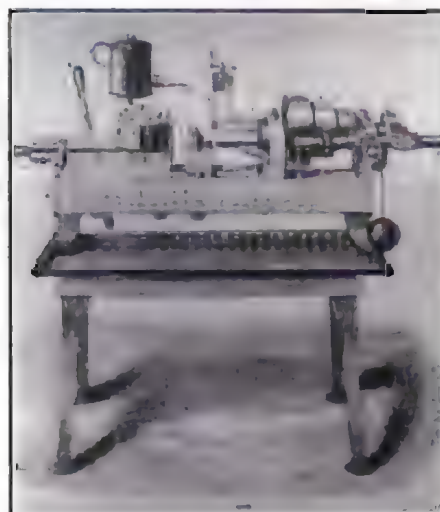
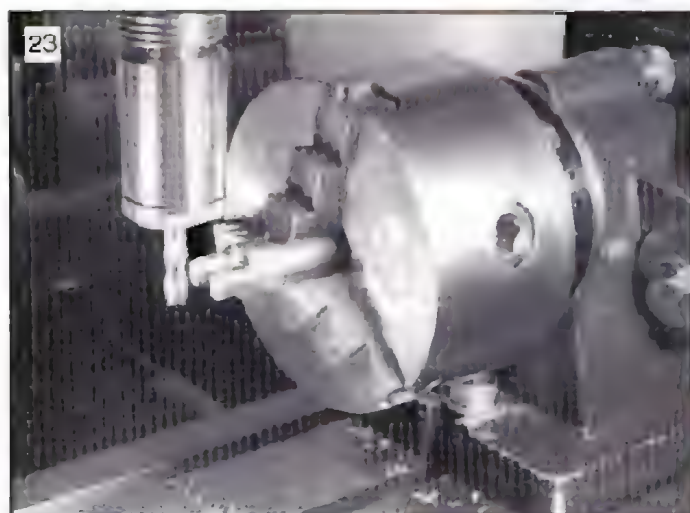
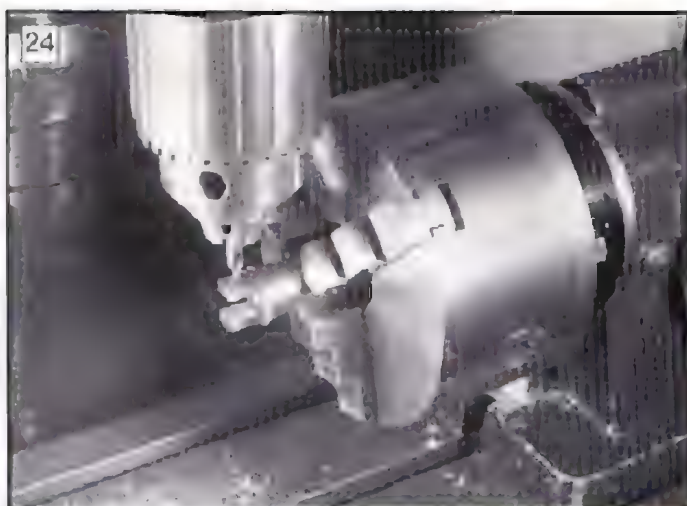
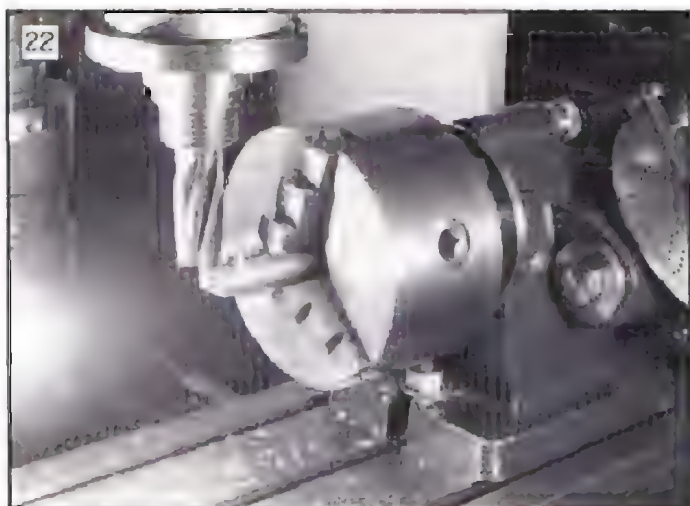


Fig. 17: A Brown and Sharpe turret (capstan) lathe. (The Engineer 1867).

A power traverse for a small milling machine **PART 2**



David Machin continues with his explanation for manufacture of the Westbury milling machine power feed.

The last stage of the mechanism is of course, the drive shaft. Using the dividing head to make the universal joints, Parts 22A and 23A, made the job easier than I anticipated. A rotary table mounted on edge would be equally effective, provided that a chuck can be mounted on it!

Grip a suitable length of $\frac{1}{8}$ in. dia. bar in the three jaw chuck face, centre and drill $\frac{1}{8}$ in. dia. for $\frac{1}{8}$ in. depth. Transfer to the dividing head on the milling machine, and mill flats on each side to a depth of $\frac{1}{8}$ in. and a length of $\frac{1}{4}$ inch. (Fig.22). This should give a central portion thickness of

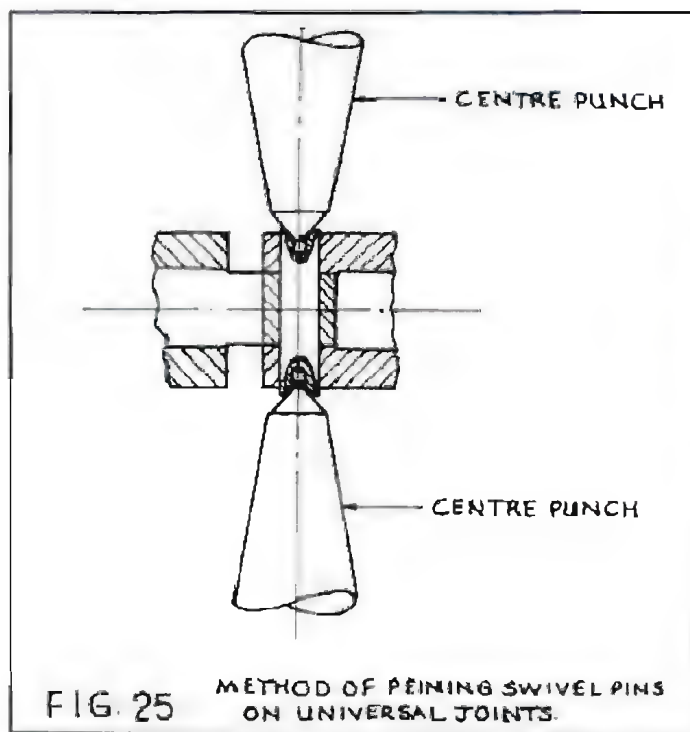
touched the bar edge. I then raised the chuck to clear the workpiece, and moved the table half the dia. of the bar plus half the dia. of the round rod using the cross slide index. This found the axis of the bar. A similar procedure can be used to determine the longitudinal position using the table index. The workpiece is then centre-drilled. (Fig.24) and drilled the appropriate size into the slot. DO NOT drill through the other side since the drill has nothing on the slot face to locate it. Instead, turn the work through 180 deg. and repeat the centre drilling and drilling. As for the two sizes of holes, this will be explained shortly. Return the chuck to the lathe and part-off the workpiece. Reverse the workpiece end for end, face off, and open up the hole to $\frac{1}{8}$ in. dia. for a length of $\frac{1}{4}$ inch. In the absence of a $\frac{1}{8}$ in. machine reamer, I drilled the holes here. Tapping 4BA for the grub screw completes this part. Two more are needed of course.

$\frac{1}{8}$ inch. Using a $\frac{1}{8}$ in. end mill, mill the central slot to $\frac{1}{8}$ in. wide. (Fig.23). Care is needed here to make sure that this slot is central. Turn the workpiece through 90 deg. and centre the workpiece under the machine spindle. An edge finder is extremely useful for this if you have one. I haven't, so I gripped a piece of round rod in the drill chuck, and moved the cross slide until the rod

The drive tube universal joint, part 23A, is made exactly in the same way as part 22A. The only difference is that the $\frac{1}{8}$ in. dia. bore is much longer! Careful centre-drilling and drilling with an accurately sharpened series of drill from, say $\frac{1}{8}$ in. dia. to reaming size should prevent problems here. Final reaming should ideally be done with a machine reamer (no taper). If you don't have one, the bore can be finished to depth with the humble drill, since the drive shaft (part 24) slides and does not turn in the bore. The 4BA tapped holes are best drilled using the milling machine. If the dividing head is used to hold the chuck and workpiece, the same centring technique, as previously described, can be used. Both holes are then centre drilled and drilled on the same axis. If drilled separately, there is a strong possibility that the holes won't be in line, the drive screws will not then enter the slot in the driveshaft without binding.

Part 22B, centre block, is next. Again, using the dividing head on the milling machine makes this easy. If your dividing head can accept the four jaw chuck, you can truly grip a piece of $\frac{1}{8}$ in. or $\frac{1}{4}$ in. square bar to machine the part. Mine won't, so I had to grip a piece of $\frac{1}{8}$ in. dia. bar in the three jaw chuck in order to machine the $\frac{1}{8}$ in. square section. This is easily carried out by indexing round for each 90 degrees. Again, the drilling position can be found using cross slide and table feed indices, as previously described. I would also strongly recommend indexing round and centre drilling each of the four faces, then indexing round again to drill the holes half way through. Any tendency to wander off centre is thus minimised. The workpiece can be returned to the lathe for chamfering and parting off.

As already mentioned, there are two sizes of holes specified: $\frac{1}{8}$ in. dia. and $\frac{1}{4}$ in.



diameter. The plan (and it worked) was to fit a $\frac{1}{16}$ in. dia. pin through one half of the universal joint and centre block; put a spot of Loctite 601 through the $\frac{1}{16}$ in. dia. hole to allow capillary attraction to draw it into the central block, thus locking the pin at this point. As a precautionary measure, I also centre drilled each end of the pin and slightly countersunk the outside of the universal joint. The ends were then pinned to prevent them coming out. This is carried out by gripping a centre punch in the vice, point uppermost. The assembly is then placed over the punch engaging the point with the centre drilled hole. Another centre punch is then put in the uppermost centre drilled hole and struck. **Fig.25** shows this. This will lock the parts. Then a $\frac{1}{16}$ in. dia. drill is used to drill through block and pin to

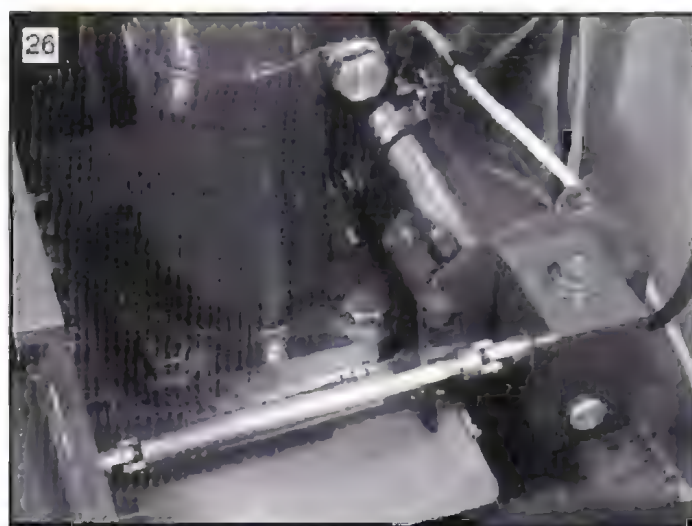
feedscrew. For the "key", two special screws were made, again from silver steel, (part 23b). These may be hardened and tempered, (to blue).

The shaft can then be assembled between gearbox and cross-slide, and a trial run attempted, after oiling round.

I used a car battery for this, and was able to measure the starting and running currents on load – these were 5 amps and 4 amps respectively.

It was eventually found, when used with the controller, that the top speed of traverse is about 2 inches per minute, dropping to $\frac{1}{16}$ in. per minute at its lowest speed.

A swarf guard has been fitted as an afterthought to reduce cleaning up time after a long milling session. This can be seen in **fig.27**, and is a very simple sheet metal exercise, and therefore is not drawn.



allow assembly of the other half of the universal joints. This time Loctite cannot be used, as it would be certain to get in those parts of the joint required to be loose. So here the peining is essential. It will now be seen why it is so important to be careful with the centring when drilling the joint parts. Silver steel pins are used to reduce wear.

To make the telescoping joints (**Fig.28**),



a $\frac{1}{16}$ in. x $\frac{1}{16}$ in. groove is machined down a length of $\frac{1}{16}$ in. dia. silver steel. The method of doing this was much the same as milling the keyway down the



Final items

First the feedscrew bearing bracket, part 35. Here, the aim was to increase table traverse as well as to completely cover the "works" as previously mentioned. The drawing shows the details, and the casting can (just) be swung over the bed of the Myford lathe. Note that there is a bronze bush fitted

to act as a bearing for the feedscrew.

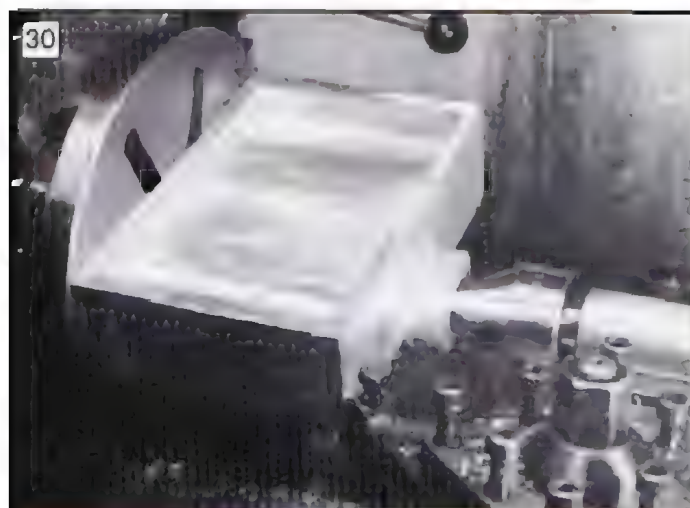
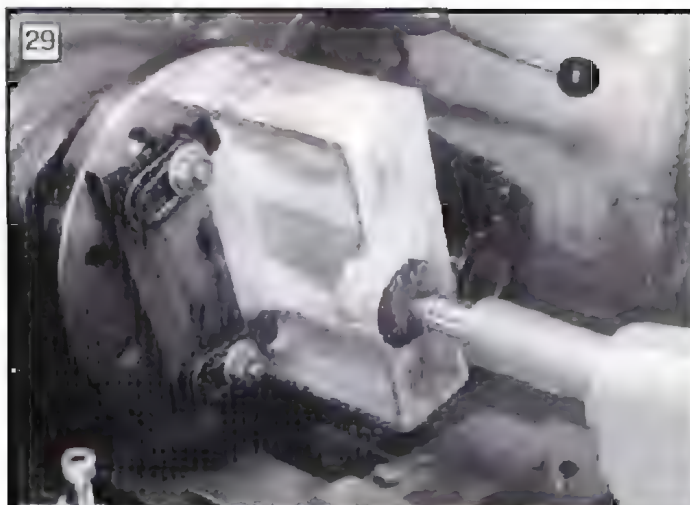
A pattern was made and an aluminium casting produced. After cleaning up the casting with a file, the first task is to remove the section of metal just above "the boss". The only reason for it being there is to facilitate casting. It can either be sawn or machined. Next, machine the bolting face flat in the milling machine. It can be either gripped in a (large) machine

vice or clamped to an angle plate, bolted to the machine table. (**Fig.28**). You will be able to try out the power feed for this!

Next, mark out for the centre of the boss, and clamp the casting to the faceplate, with the (now) flat bolting face against the faceplate. Line up the marked centre with a centre point in the tailstock, and tighten the clamp bolts (**fig.29**). With very light cuts, face the boss. Then centre drill, and support this end of the casting on a lubricated or revolving centre. The rest of the face can now be machined flat, and the boss turned to $\frac{1}{16}$ in. dia. (**Fig.30**). The centre hole can now be drilled, bored and recessed ready to receive a bronze bush. Finally, it will be necessary to face the back of the boss. This can be carried out with a specially made tool, (**fig.31**). Great care with the feed is needed here, or the casting could be moved out of position.

If the face plate is now removed (still with the casting bolted to it), the bush can be machined, (in the three jaw chuck), to a light press fit in the casting.

I consider a light press fit as size for size, i.e., if the boss is 0.5625in. then the bush is machined to 0.5625in. (if the bore has been



using a vice or sturdy G clamp as a press.

A smear of Loctite 641 would be helpful, too.

Remount the faceplate, centre drill, carefully drill and ream the centre hole. The datum line for the index can conveniently be put on now. I use a V thread screwcutting tool for this.

Mounted on its side at centre height in the tool post this can then be used to scratch the datum line using either top

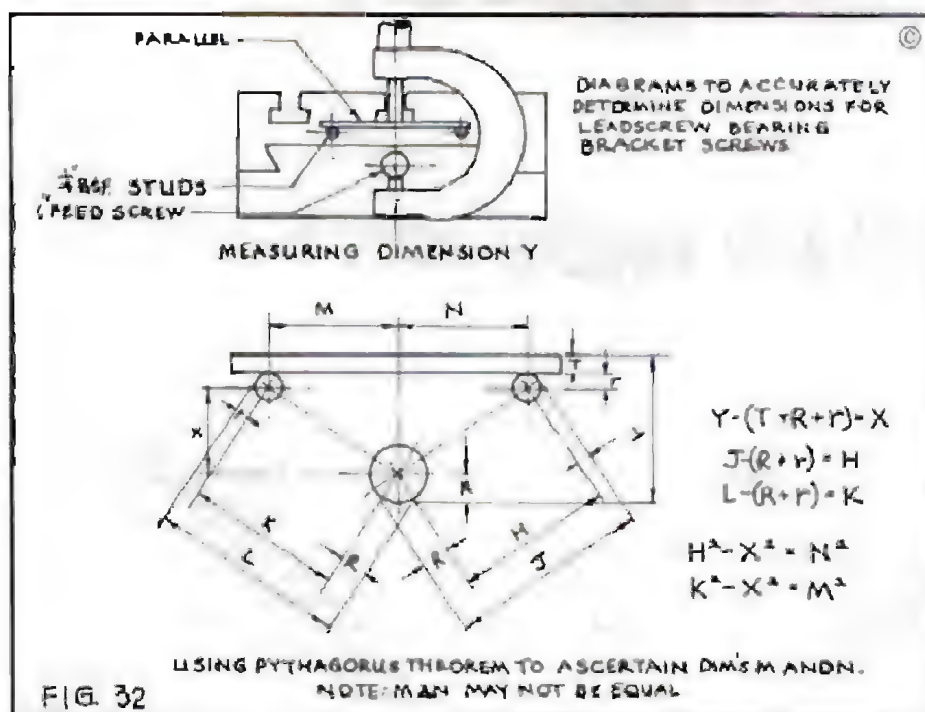
adopted successfully. First remove the old bearing bracket and measure the hole positions relative to the feedscrew. I made up some short studs for this from pieces of $\frac{1}{16}$ in. rod. The measurements were then carefully taken using a micrometer, a parallel, and the set up shown in fig.32. Pythagorus theorem will then give the required dimensions.

Next, make a drilling jig from a piece of mild steel plate, at least $\frac{1}{16}$ in. thick. This can be clamped to your milling machine table – parallel to the tableways – with parallel packing underneath (exactly as was used for the motor plate). Using the milling machine's table and cross slide movement indices can now give the exact positions of the three holes, using the same method as described for the motor plate.

Care is needed when indexing from one hole to the next, to avoid loss of accuracy due to backlash. The upper face of the jig should be marked so that it can be located the correct way round.

If the bracket is (yet again) dismantled, the jig can be used to check alignment. If all is well, the jig can now be used to drill the holes in the casting, taking care to assemble the right way round. I used the old feedscrew to locate the jig as seen in fig.33. The cone nut (tightened up) will hold the feedscrew in position. The jig can then be slipped over the feedscrew, (marked side towards the bolting face) lined up with the top face of the casting and clamped. The feedscrew can then be removed to allow drilling to take place. In order to counterbore the holes to receive the screw heads, it will be necessary to drill holes in the opposite face. Again, the jig can be used for this, but will need packing since the boss is in the way. Once drilled, the $\frac{1}{16}$ in. holes can be enlarged to $\frac{1}{8}$ in. to allow this size of drill to be used to counterbore for the screwheads. Because this will leave a conical seating, regrinding the drill to give a flat face will be necessary (fig.34), unless you have a long spot-facing cutter or end mill.

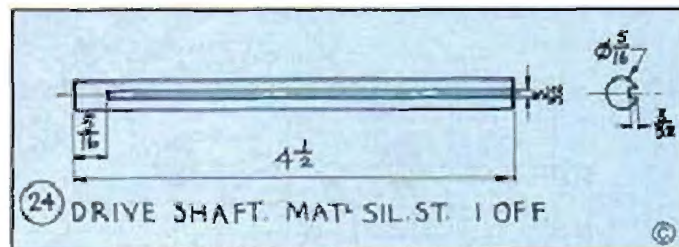
The casting can now be bolted to the table and the leadscrew fitted to check alignment. I must confess that I was amazed that the fit was so good; I expected to have to at least drill $\frac{1}{16}$ in. to allow for any slight error, but this was not needed. Whilst this trial assembly is taking place, it is a good plan to scribe round the table contours onto the bolting face. This will then indicate where metal needs removing to clear the Tee slots, slides, etc. Also, since as T way is to be screwed to the front



reamed, then the size will be at least 0.5855in. I always machine the first $\frac{1}{16}$ in. or so, along the length to a push fit, so that the bush can be started in the hole. A push fit, for me, is 0.003in. smaller than the bore. The shoulder for the recess can also be a push fit. (Do not bore the $\frac{1}{16}$ in. hole at this stage). Pressing in the bush can be carried out still with the casting on the faceplate,

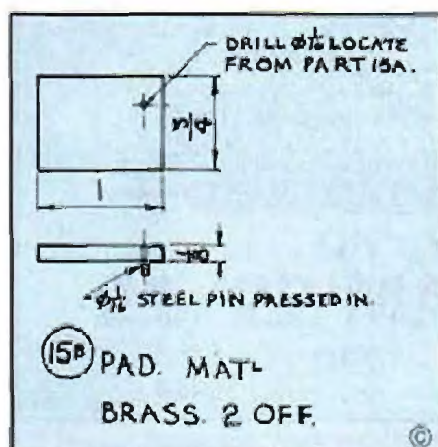
slide feedscrew or carriage handwheel. The casting can now be removed and the oil hole drilled, and counterbored. A $\frac{1}{16}$ in. dia. reamer will remove the internal burr.

The method of bolting the casting to the table is to use the same tapped holes that held the original. The problem is to make sure that the holes in the new casting will exactly line up. The following method was

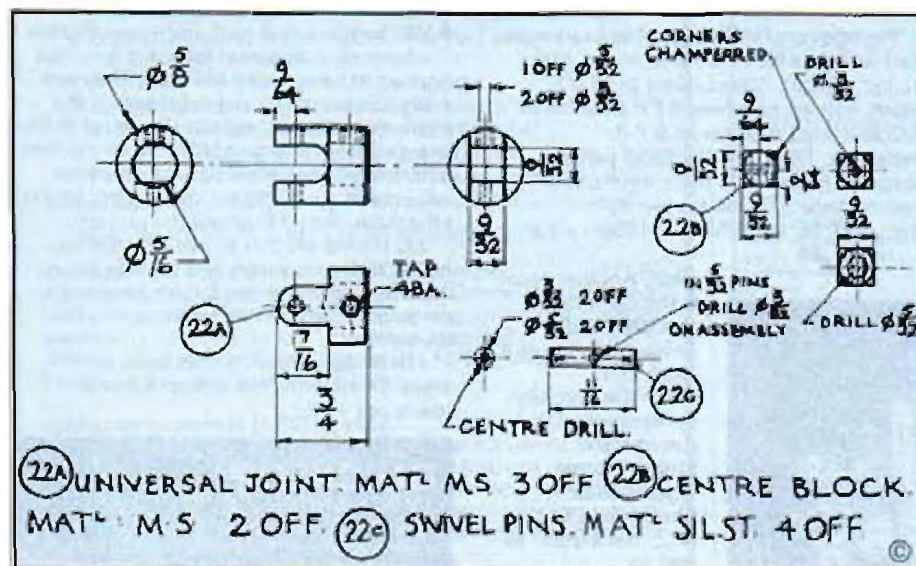
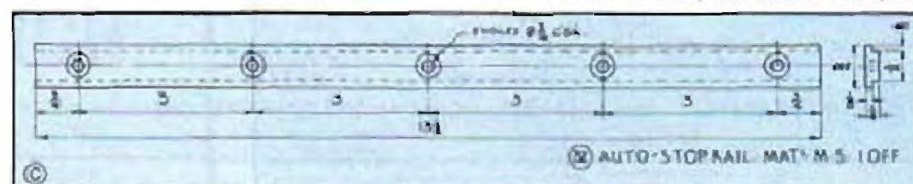


think it is really necessary because by riveting two pieces together you can achieve the same end with a lot less effort and time. The drawing shows all necessary details, part 32.

The autostop blocks (part 15A), are made from pieces of 1in. square mild steel. Brass would be much easier to machine, if you have a piece. The Tee sections are machined in two stages, see **fig.35**. Pieces of brass strip 1/4in. thick are used to act as pads (part 15B) for the screws. The cams themselves (lower edge of part 15A) are worthy of comment. I made the first one from gauge plate using SBA screws to hold it in position. For the second, I simply contoured the mild steel. On balance, the amount of wear is going to be so small that harder metal is hardly warranted. It may be



The last job is the auto stop system. For this I machined grooves in a solid piece of annealed mild steel, but I don't

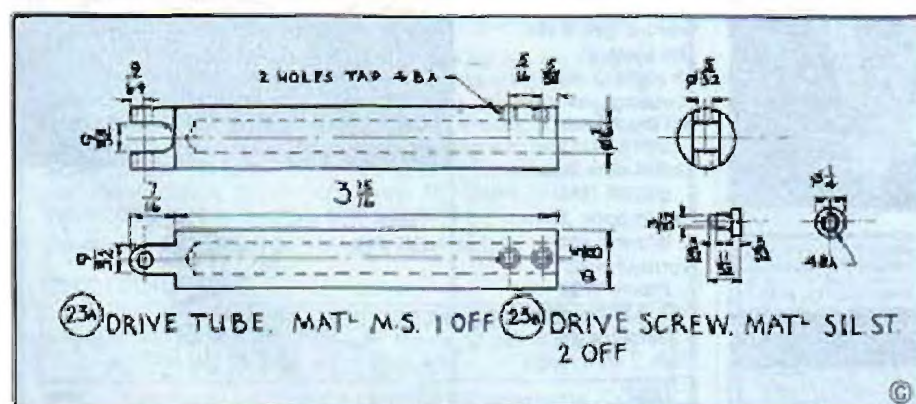


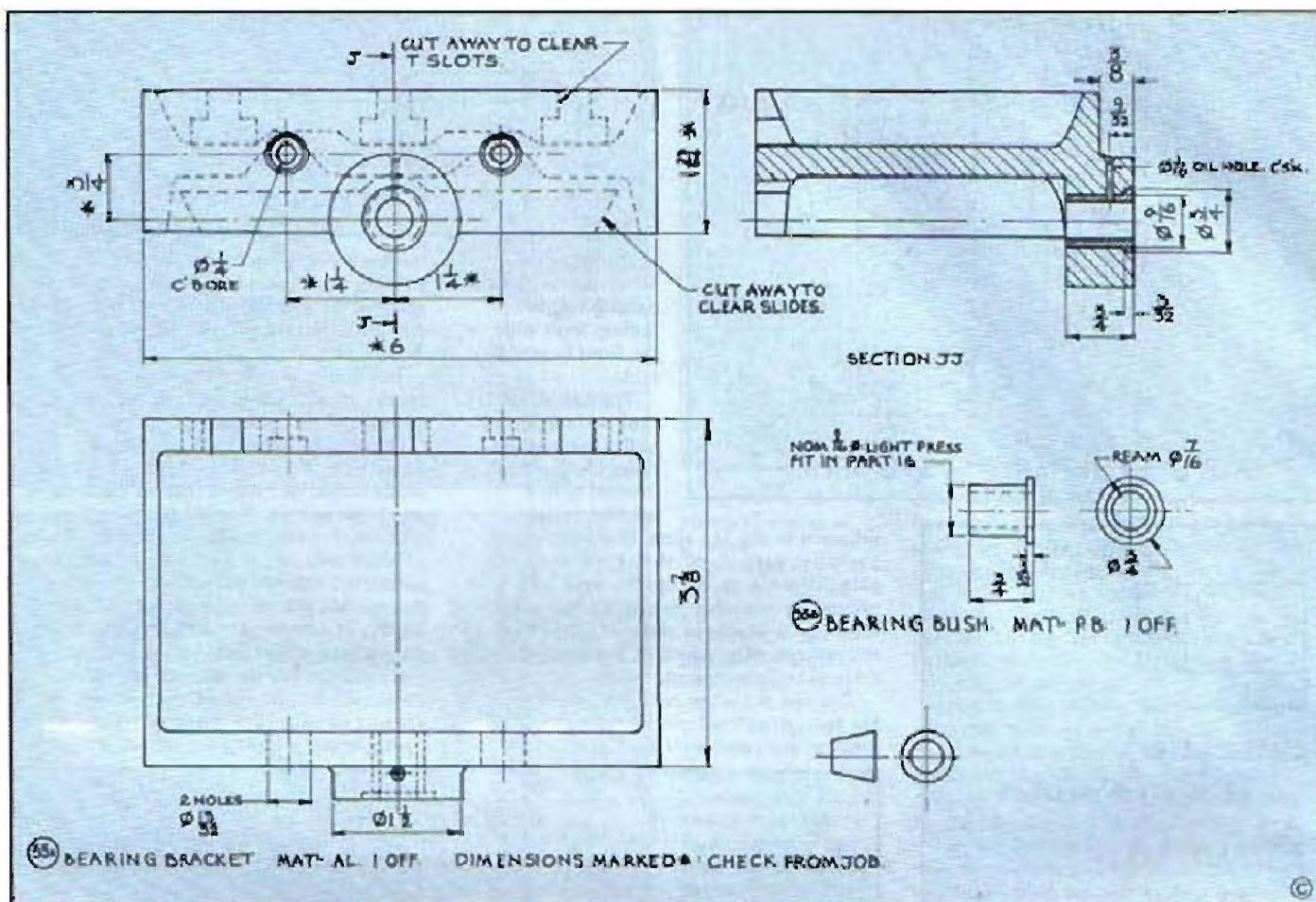
A few variations on a theme

That completes the version for the Westbury. Now some notes on commercially available gears, for those who want to buy wormwheels and possibly make their own worms.

One problem with commercial wormwheels of 32 D.P. is that the boss and bore sizes are too small for our needs. Since the material used is phosphor bronze, it should be possible to modify them in two ways: (1) soft solder on an additional piece; or (2) with great care, silver solder on an additional piece. This would need a low melting point solder, of course, say around 600 deg. C. I would recommend the latter option. Once this is done, machining can be carried out, bearing in mind the need for concentricity with the worm teeth, particularly when machining the bore.

Another problem is machining a worm to match a standard D.P. This gives a very non-standard circular pitch. In the case of 32 D.P., this is 0.0982 inch. At first sight, this would appear impossible, since the lathe changewheels would appear not to be able to give the ratios required. Not so, it can easily be done. I claim no credit for the following. It comes from L.C. Mason's book: *Using the Small Lathe* – a M.A.P. publication – and an absolute mine of information. In this he explained how to get over the above problem, involving π in the changewheels. The formula is: set up to screwcut a T.P.I. equivalent to half the D.P., and introduce a 55:35 pair of changewheels into the train ($\frac{\pi}{2} \times 2 = 3.1429$, $\pi = 3.1416$).





Very close - Ed). In our case for 32 D.P. this becomes 16 T.P.I. So for an 8 T.P.I.

leadscrew the gears are $\frac{40}{80} \times \frac{55}{35}$. The 40T

going on the top stud, the 80T and 55T keyed together on the intermediate, and the 35T gear on the leadscrew shaft. The 40 drives the 80, and the 55 drives the 35.

To prove this: multiply the above train by the leadscrew pitch, thus:

$$\frac{40}{80} \times \frac{55}{35} \times 0.125\text{in.} = 0.0982\text{in.}$$

A very clever concept. I wish I had thought of it!

The above, of course, applies to a single start worm so for a two start worm, the lead (2 x pitch), is equivalent to 16 D.P. which, halved, becomes 8 T.P.I., which of course is a 1:1 ratio for an 8 T.P.I. leadscrew. Thus only the 55:35 pair are needed. The set up is then: top stud: 55T; Intermediate: any, leadscrew: 35T.

$$\text{The proof: } 55 \times 0.125\text{in.} = 0.1984\text{in.} = 2 \times \frac{1}{35}$$

pitch. Another point is the commercial availability of universal joints as a stock item.

Hinchliffe Precision Components Ltd, Avenue Six, Storforth Lane Trading Estate, Chesterfield S41 0QZ, have these as well as wormwheels, worms, gears etc. The sizes of universal joints, (or couplings, as they call them) are:

U813A O/D:

13mm bore: 8mm

U816A O/D:

16mm bore: 10mm

Worms and

wormwheels:

Worm W32 - 2

O/D: 0.662in. bore:

0.250in; length

1 1/4in. 2 start: steel

(EN202) unhardened.

Wormwheel: m-32-24; PCD 0.750in; throat dia: 0.813in; Boss dia: 0.5in; bore:

0.187; length 1/2in; 2 start, phosphor Bronze.

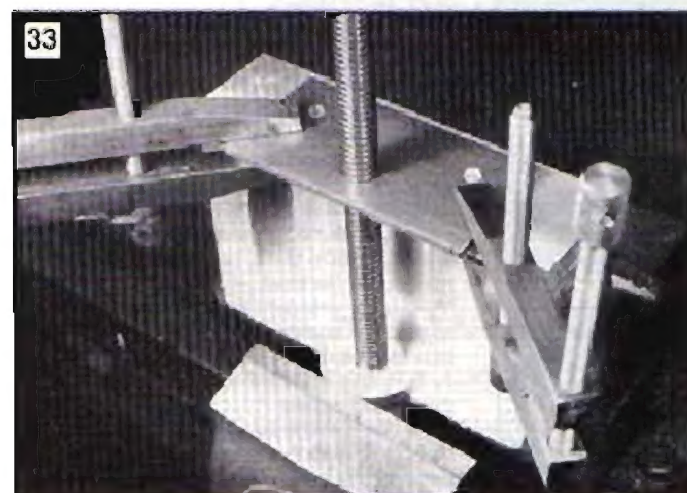
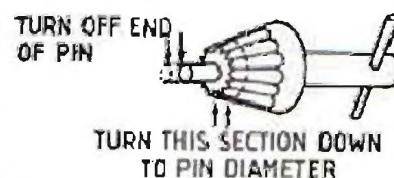
I have no connection with this firm, but happen to have their catalogue. They are willing to supply model engineers in the small quantities we require. However there is a minimum charge of £15. So for readers who are perhaps short of time, this firm will enable you to obtain those parts which, otherwise, would frustrate the project.

My thanks are due to Janice Little for typing this manuscript, and once again, to my wife Carole, for her forbearance in my pursuits at the drawing board and in the workshop.

(To be concluded in next issue with ideas for adapting the design for other machines - Ed.)

QUICK TIP

Being relatively soft and working against a hardened chuck the keys wear and are fairly expensive to replace particularly for the larger chucks of 1/2" and over. An old worn out, rounded toothed key can be given a whole new lease of life by simply turning back the worn face and the end of the pin so that they key meshes deeper into the chuck.



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